RPT-178
Revision 0

The Drilling, Coring, and Installation of Two Deep Monitoring Wells (MIDDLE 2051 and MIDDLE 2050A) in Fiscal Year 2005

June 2006

Idaho Cleanup Project

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The Drilling, Coring, and Installation of Two Deep Monitoring Wells (MIDDLE-2050A and MIDDLE-2051) in Fiscal Year 2005

June 2006

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for the
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Assistant Secretary for Environmental Management
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ABSTRACT

This report documents recent drilling, coring, and well construction activities conducted at two locations near the Radioactive Waste Management Complex and between the Reactor Technology Complex and the Idaho Nuclear Technology and Engineering Center at the Idaho National Laboratory. This report summarizes the work performed and data gathered from January 18, 2005, through October 3, 2005. The project consisted of the drilling, coring, and installation of two new deep corehole-monitoring wells, MIDDLE-2050A and MIDDLE-2051, located southerly adjacent to the Big Lost River. The coreholes were drilled through surface sediments and cored through the underlying basalt flows and interbeds to a depth of 1,427.4 ft below land surface in the MIDDLE-2050A well and 1,179 ft below land surface in the MIDDLE-2051 well.

The wells were completed with the Westbay Multilevel Groundwater Monitoring System and will provide future information for the Operable Unit 10-08 remedial investigation/feasibility study of potential contaminant transport, water chemistry variations, and water level changes within the Snake River Plain Aquifer over time. Both wells were cored through the active portion of the aquifer. The depth of the water table in the MIDDLE-2050A well was 481 ft below land surface, and the depth to water in the MIDDLE-2051 well was 571 ft below land surface. The interpretive bottom of the aquifer in both coreholes was based on antigenic pore mineralization in what appears to be geothermal-altered basalts.

CONTENTS

FIGURES

ACRONYMS

bls	below land surface
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
DOE-ID	U.S. Department of Energy Idaho Operations Office
DR	dual rotary
ESRP	Eastern Snake River Plain
HSO	health and safety officer
ID	inside diameter
IH	industrial hygienist
INEEL	Idaho National Engineering and Environmental Laboratory
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
JSA	job safety analysis
OD	outside diameter
OU	operable unit
RI/FS	remedial investigation/feasibility study
RWMC	Radioactive Waste Management Complex
SPC	specification
SRPA	Snake River Plain Aquifer
USGS	United States Geological Survey
WAG	waste area group

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1. INTRODUCTION

Two new aquifer-monitoring wells were drilled and cored at locations near the Radioactive Waste Management Complex (RWMC) and between the Reactor Technology Complex and the Idaho Nuclear Technology and Engineering Center (INTEC) at the Idaho National Laboratory (INL). The information obtained from this project will give more accurate representation of subsurface conditions for use in the Operable Unit (OU) 10-08 remedial investigation/feasibility study (RI/FS). The wells were installed to provide multiple monitoring points in the aquifer. The monitoring points will be used for understanding vertical variations in the aquifer, including contaminant transport, water chemistry variations, and water level changes within the Snake River Plain Aquifer (SRPA) over time.

The two wells drilled and cored through the aquifer are MIDDLE-2050A (Well ID 2050) and MIDDLE-2051 (Well ID 2051). The MIDDLE-2050A well was drilled and cored approximately 3/4 mi west of INTEC, 1/2 mi off Lincoln Boulevard along a dirt access road just south of the Big Lost River. This well was drilled to a total depth of 1,427.4 ft below land surface (bls). The water level in this well was measured to be 481 ft bls. The MIDDLE-2050A well also is located approximately 32 ft N 25°E of the original MIDDLE-2050 location. The MIDDLE-2050 well was drilled and cored to 385 ft bls and was abandoned and plugged because of the lost portion of core string in the corehole between 274.5 and 295.5 ft bls. The MIDDLE-2051 well is located approximately 1-1/4 mi south of U.S. Highway 20 on T-12 road, just south of the Big Lost River, and 2-3/4 mi northeast of the RWMC. This well was drilled and cored to a total depth of 1,179 ft bls with the water level measured at 571 ft bls. Both completed coreholes were developed using down-hole pumps and packers. The wells were installed using the Westbay MP55 System™ with multiple-level packers, ports, and polyvinyl chloride pipe.

2. BACKGROUND

2.1 Site Background

The INL is a U.S. Department of Energy (DOE) facility located 52 km (32 mi) west of Idaho Falls, Idaho, and it occupies 2,305 km² (890 mi²) of the northeastern portion of the Eastern Snake River Plain (ESRP) (Figure 1). The INL was established as the National Reactor Testing Station in 1949. Since that time, the INL has operated under different designations as a testing and research center. Historically, research and testing at the INL have been primarily concerned with nuclear energy. Comprehensive INL historical and geological information relevant to the INL is provided in the *Waste Area Group 10, Operable Unit 10-08, Remedial Investigation/Feasibility Study Work Plan (FINAL)* (DOE-ID 2002).

Under the *Federal Facility Agreement and Consent Order for the Idaho National Engineering Laboratory* (DOE-ID 1991), OU 10-08 is responsible for determining the nature and extent of contamination and potential risks to human health and the environment posed through the SRPA. The OU 10-08 groundwater studies address groundwater flow and contamination across the INL, including all areas outside the boundaries of the other individual waste area groups (WAGs), and the groundwater studies consider the potential for risk created by commingling of residual plumes left by those WAGs. The purpose of the WAG 10, OU 10-08 RI/FS is to provide a comprehensive evaluation of environmental impacts from operations at the INL to the underlying SRPA.

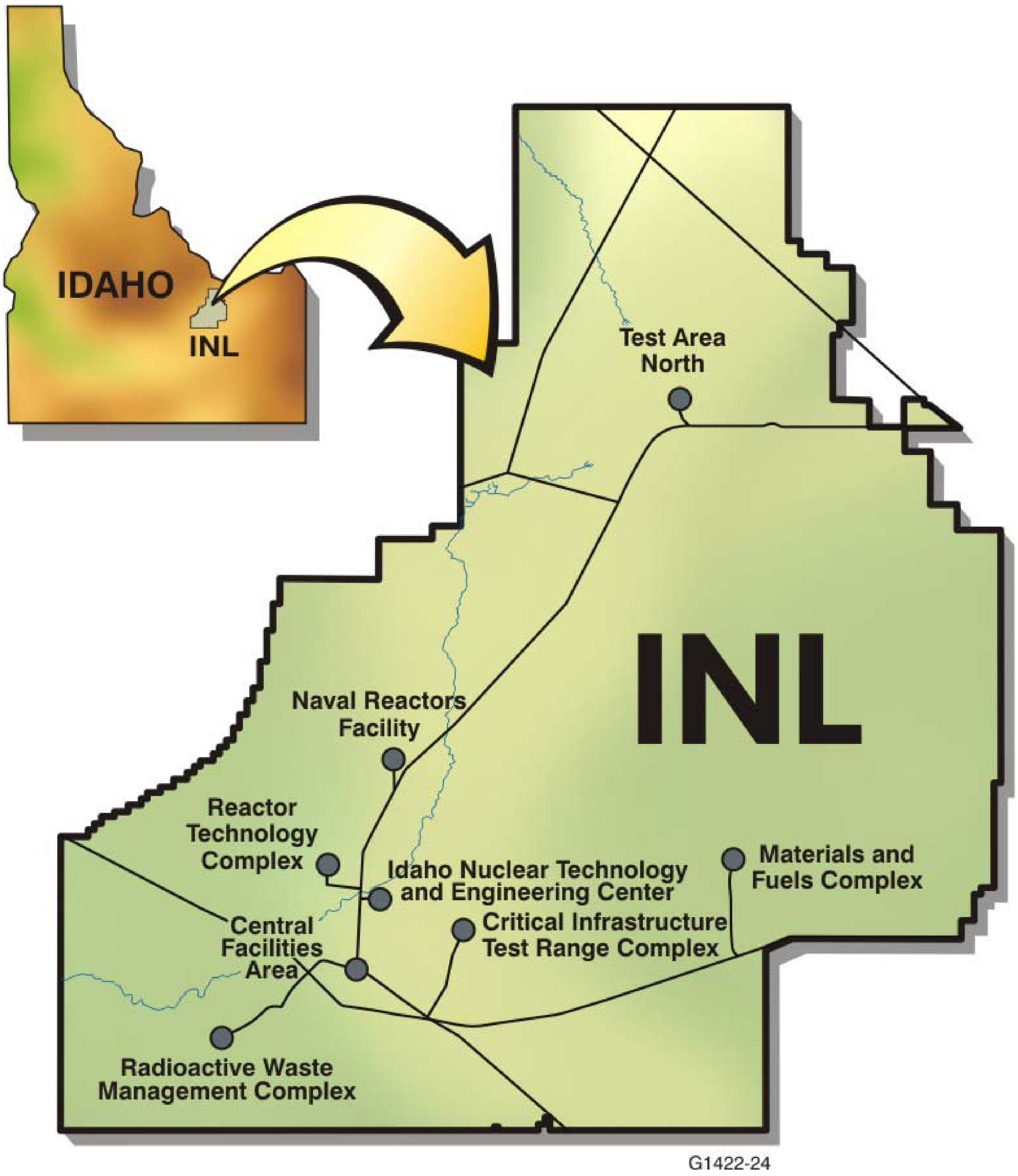


Figure 1. Map of the Idaho National Laboratory area.

The scope of the OU 10-08 remedial investigation includes comprehensive investigation and characterization activities to perform the following activities:

- Fill data gaps identified in the *Idaho National Engineering and Environmental Laboratory Operable Unit 10-08 Sitewide Groundwater Model Work Plan* (DOE-ID 2004) and in the *Waste Area Group 10, Operable Unit 10-08, Remedial Investigation/Feasibility Study Work Plan (FINAL)* (DOE-ID 2002)

- Obtain adequate data to prepare the OU 10-08 RI/FS and subsequently the OU 10-08 Record of Decision.

2.2 Environmental Setting

The surface of the INL is relatively flat with the predominant relief manifested either as volcanic buttes jutting from the desert floor or as unevenly surfaced basalt flows, flow vents, and fissures. With the exception of the buttes on the southern border of the INL, elevation levels on the INL range from 4,790 ft in the south to 5,913 ft in the northeast with an average of 5,000 ft above sea level (Irving 1993). The area is classified as a semiarid sagebrush desert with precipitation of 9 to 13 in./yr. Yearly temperatures are consistent with western mountain valleys. Warm, dry summers followed by cold winters on the relatively flat topography help to develop frequent gusty winds during all times of the year.

2.3 Geological Setting

The coreholes are located on the ESRP in the Big Lost River alluvial deposits overlying basalt bedrock. The sediments composing these deposits are thin, silty sand top soil (loess) deposits overlying a thick primarily alluvial sand and gravel deposit. The depth to the basalt in this area ranges from 10 to 60 ft bls.

The Snake River basalt that underlies the surface sediment is a thick sequence of interfingering basalt flows that contain interbedded sediments of clay, silt, sand, and gravels. Basalt flow thickness at the INL is generally less than 30 ft (Anderson, Kuntz, and Davis 1999). The basalt varies from being highly vesicular to very dense and from being highly fractured to massive. Occasional cinder zones of pyroclastic deposits represent near-source vents.

The fine-grained sedimentary interbeds present between some basalt flows are the result of deposition during periods of volcanic quiescence. The composition of the interbeds consists mainly of silty sand, clayey sand, sand, silty sandy gravel, and sandy gravel. The multiple interbeds in the coreholes range in thickness from 0.5 to 98 ft thick.

2.4 Hydrology

Surface hydrology at the INL includes water from three streams that flow intermittently onto the INL and from local run-off caused by precipitation and snowmelt. Most of the INL is located in the Pioneer Basin into which three streams drain (i.e., the Big Lost River, the Little Lost River, and Birch Creek). These streams receive water from mountain watersheds located to the north and northwest of the INL. Stream flows often are depleted before reaching the INL by irrigation diversions and infiltration losses along stream channels. The Pioneer Basin has no outlet; therefore, when water flows onto the INL, it typically either evaporates or infiltrates into the ground (Irving 1993).

The SRPA is defined as the saturated portion of a series of basalt flows and interlayered pyroclastic and sedimentary materials that underlie the ESRP. The SRPA at the INL ranges from approximately 200 ft bls in the north to more than 900 ft in the south (Irving 1993). The SRPA is recharged primarily by infiltration from rain and snowfall that occurs within the drainage basins surrounding the ESRP and from deep percolation of irrigation water. Annual recharge rates depend on precipitation, especially snowfall.

3. WORK PERFORMED

The Drilling Services Division of Major Drilling of Salt Lake City, Utah, was contracted to do the drilling and coring and assist in well construction of the MIDDLE-2050A and MIDDLE-2051 wells. Specification (SPC) -631, "Drilling, Coring, and Installation of Wells MIDDLE-2050 and MIDDLE-2051 at the INL," provided the technical and functional requirements needed to perform the work in a responsible manner and provided the guidelines for design parameters and funding authorization for the borehole from surface soils to basalt bedrock and the total depth cored.

In accordance with the requirements presented in the "Occupational Safety and Health Standards" (29 CFR 1910) and "Hazardous Waste Operations and Emergency Response" (29 CFR 1926.65), the *Health and Safety Plan for the Long-Term Stewardship Sitewide Groundwater Monitoring* (Gurney 2004) was reviewed and followed during this project. This Health and Safety Plan governed the execution of all fieldwork performed by INL employees and subcontractors. All members of the project team performing work at the site reviewed and signed off on this Health and Safety Plan. Each subcontractor also provided a job safety analysis (JSA). The subcontractor personnel reviewed and signed off on the JSAs, which are kept on file at the job site along with a copy of the daily prejob briefing attendance records.

3.1 Drilling and Equipment Used

Two drill rigs were used to drill each hole. A Foremost DR-24 dual rotary (DR) reverse-circulation, air-rotary drill rig was used to set surface casing. This drill rig has two drives: (1) a top head drive for advancing the carbide-button hammer bit and drill rods and (2) a lower drive for advancing the DR casing. A 7-in., dual-wall drill pipe was used during drilling to advance various-sized hammers and bits. The DR casing used was that of 16-in. carbon steel with a 16.5- to 17-in. cutting shoe advanced to the top of the basalt to stabilize the borehole throughout the surface soil and overlaying fluvial gravels. This casing was replaced with 12.75-in. carbon steel surface casing, including a 3-ft monument stickup during surface completion.

The UDR-1500 rotary drill/core rig was used for continuous coring and 19.7-ft-long sections of 134 core rods were attached to a 10-ft outer core barrel and PQ core bit. The core was retrieved from inside the core rod using an overshot latching tool, on wire line, to pull the inner core barrel out of the corehole. Initially, the inner barrel had stainless-steel split sleeve to aid in undisturbed core removal from the inner barrel. The core was removed from this inner barrel using forced water to pump it out on a core rack or between two drill rods. The stainless-steel split sleeves were removed to help keep the core from jamming inside the inner core barrel. An oversized PQ core bit was used with an outside diameter (OD) of 5.9 in. and inside diameter (ID) of 3.27 in. A 6-in. reamer/stabilizer also was attached to the sub and core barrel. The core runs were conducted to a maximum of 10 ft per run in length.

Other equipment supplied by the drilling contractor included an auxiliary air compressor, a boom truck, water truck, a forklift, supply trailers, cement mixer, and pickup trucks. Water for coring was obtained from the Fire Station Well, located north of INTEC. The boom truck and forklift were utilized to transport and unload the drill rods, casing, and well construction materials. The boom truck also was used in raising and lowering steel tremie pipe while building the wells. Details of drilling and the equipment used are found in Section 4 and in the General Well Information forms in Appendix B.

3.2 Geological Logging

Samples of drill cuttings were retrieved throughout the drilling of each corehole for the purposes of describing the lithology encountered. Drilling conditions and rate of penetration also were observed in the interpretation of lithology changes, zones of fractures and rubble, and to determine the progress of the drilling. The reverse-circulation method allowed for depth-accurate collection of drill cuttings because of the direct return of cuttings through the drill steel from the drill bit, reducing the mixing of cuttings Cuttings were collected at approximate 5-ft intervals or when there was a change in rock type or drilling rate from the discharge hose using a coarse screen sieve.

The core was recovered from the inner core barrel using pressured water to push it from the inner core barrel. Stainless-steel sleeve was used at first to maintain an undisturbed orientation of the core as it was pushed from the inner core barrel. These were removed because of the core jamming inside the barrel. The core was pushed out between two drill rods under the supervision of the rig geologist. The core was then placed in plastic core boxes holding up to 5 ft of core, in 2.5-ft lengths, oriented from top to bottom of the core. The core was marked with parallel lines of permanent red and blue/black ink. The red line was placed on the right with the top of the core box positioned vertically. The core was placed in the core boxes from left to right. Each core box was labeled using permanent ink with the well name, box number, and interval footage of core contained in the box. The core run and footage also were marked on the core with marked dividers between each core run.

The drill cuttings and cores were described by the rig geologist and documented in the Record of Corehole Logbook on log forms bound in the book. Sediment and rock descriptions included colors' (in reference to the Munsell soil color and the GSA's rock color charts) density, accessory minerals, vesicle frequency, fractures, mineralization, alteration, and infilling. Surficial soils and sedimentary interbed materials were described in general accordance with the Unified Soil Classification System. Lithologic descriptions of MIDDLE-2050, MIDDLE-2050A, and MIDDLE-2051 are found in Appendix A. Lithologic logs are included in the data completion diagram in Appendix C.

3.3 Geophysical Logging

The United States Geological Survey (USGS) performed geophysical and video logging of both completed coreholes for this project. When the coreholes were drilled to an intermediate casing depth or to total depth, the drill string was removed from the borehole and a video camera was used to video log the boreholes from surface, including the down-hole DR casing, and the open borehole to total depth drilled. A small, portable onsite camera was used for down-hole when the USGS was unable to come to the drill site. In addition to the video logging, the logs selected to enhance the geologic data obtained during the drilling were natural gamma and caliper. The neutron and gamma-gamma log and well bore deviation gyro log were run inside the 134 (PQ) rods. Other down-hole logging included resistivity, temperature, and flow meter. Information regarding the type of log runs, interval, and dates can be found in Appendix B of "General Well Information." Additional information also is recorded in Section 4 under "Drilling Activity."

The USGS and the Hydrogeologic Data Repository/Comprehensive Well Inventory of the INL keep copies of all the videotapes and geophysical logs. The geophysical log profiles are shown in Appendix C.

3.4 Well Completion

Well completion of MIDDLE-2050A and MIDDLE-2051 took place at the end of the coring. Completion included surface casing installation with a monopod mounting bracket, well development/purging with initial sampling of the aquifer, and well installation of Westbay's multilevel groundwater monitoring system. The monopod mounting bracket is a Westbay component that is used to attach a monopod that allows the operator to lower the MOSDAX sampling probe into the well. After each corehole reached total depth and finished being logged, the lithology, geophysical logs, and video logs were reviewed to determine the best sampling interval. This information was forwarded to Westbay's technicians for help in determining which components needed to be sent for installation. Final completion of the wellheads included pouring a concrete pad around the surface casing, with a brass marker set in the pad for well identification, and placing three guard posts set around the wellhead.

The original corehole, MIDDLE-2050, was plugged and abandoned using bentonite to seal the corehole interval, including the lost portion of the core rod, core barrel, and bit. See Section 4.2, "MIDDLE-2050 End of Core Report," for details.

3.4.1 Well Development

Upon completion of coring MIDDLE-2050A and MIDDLE-2051, each corehole was purged using down-hole pumps and packers to isolate targeted zones of sampling. This was done in order to remove coring additives (1 cup of Quik-Foam to 500 gal of water pumped while coring), cuttings, and suspended interbed sediments from below the aquifer inside the corehole. Purging was in excess of three times the well volume at every interval pumped in each well. Field parameters (i.e., pH, dissolved oxygen, temperature, conductivity, and turbidity) of the water produced were recorded using a hydrolab connected to a laptop computer, using the Hydras 3LT program. Field parameters were allowed to stabilize before purging was halted.

Information pertaining to pump specifications, intervals of well development, water clarity, and volumes pumped for both wells can be found in Appendix B under "Well Development." More details can be obtained in both the field Sample Logbook and the field Record of Corehole logbooks. Initial water samples that were taken before installation of the Westbay monitoring systems are listed in the field Sample Logbook ER-007-2005, "WAG 10 Corehole Project (MIDDLE-2051, MIDDLE-2050A)."

3.4.2 Well Installation

The MIDDLE-2050A and MIDDLE-2051 wells were installed by Major Drilling's crewmembers using the UDR-1500 core/drill rig and under the supervision and direction of Westbay's technical representative onsite. All the components used for each well were carefully inventoried and measured for accurate down-hole placement prior to installation. Those who assisted underwent training prior to the well installation. Both wells were completed with the MP55 System™ multilevel monitoring system using casing, packers, and sampling ports. Westbay Instruments, Inc. prepared a completion report for the two wells giving specific information of installation, and it is included in Appendix F of this report.

4. END OF WELL REPORT

This section provides a summary of drilling and coring activities of the MIDDLE-2050, MIDDLE-2050A, and MIDDLE-2051 wells. It also provides information related to work documents, the drilling company, personnel involved in the project, drilling and completion equipment, materials used in building the wells, and problems encountered. Figure 2 is a map of the locations of MIDDLE-2050, MIDDLE-2050A, and MIDDLE-2051.

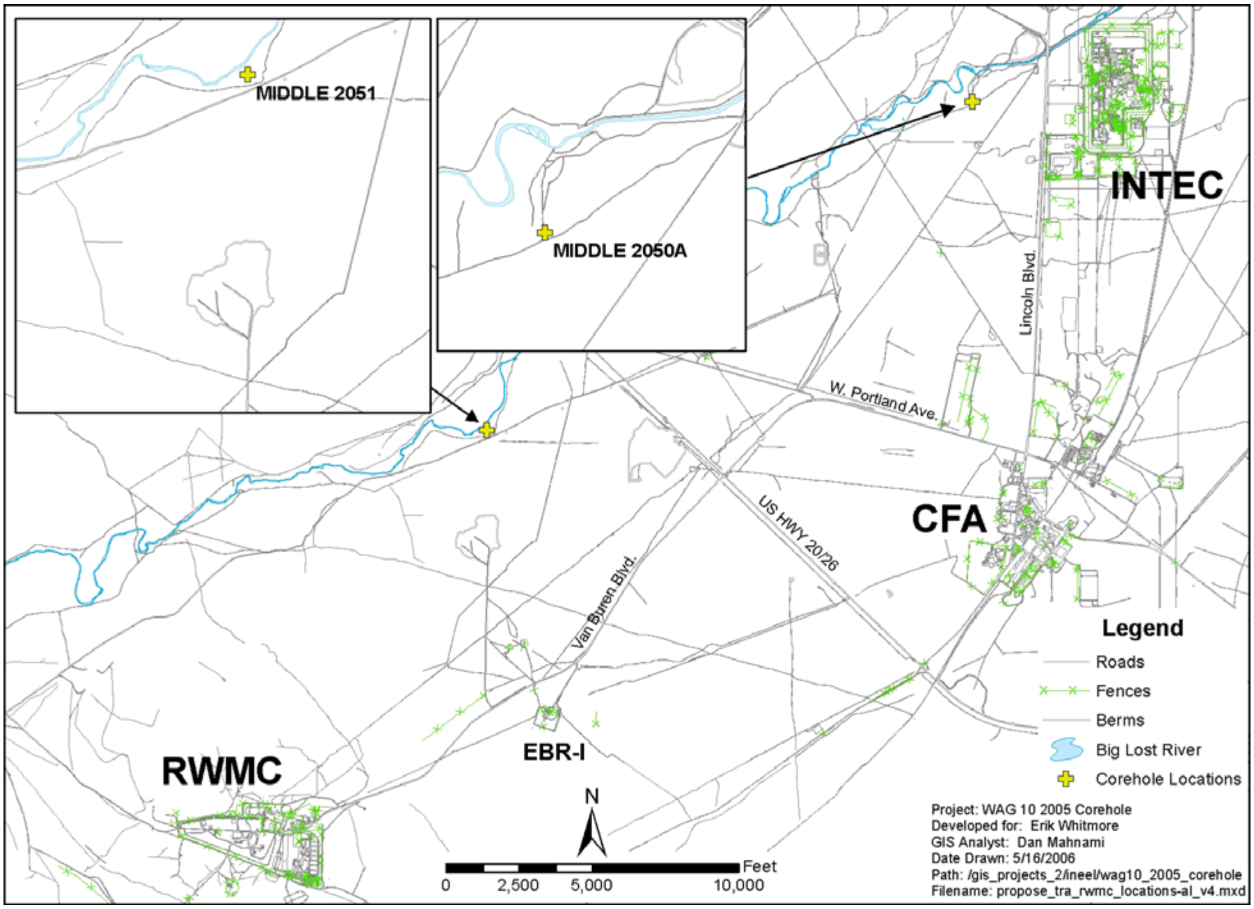


Figure 2. Map showing the locations of MIDDLE-2050A and MIDDLE-2051; note that MIDDLE-2050 is located 32 ft southwest of MIDDLE-2050A.

4.1 MIDDLE-2050 End of Core Report

4.1.1 General

The drilling of Well MIDDLE-2050 was initiated on May 24, 2005. Coring reached a total depth of 385 ft bls. The core rods became stuck at a depth of 290 ft bls. The rods were cut at a depth of 275 ft, leaving 15 ft of rod in place. The hole was abandoned using bentonite, with a cement plug at the top of the borehole. The MIDDLE-2050 well was replaced with the MIDDLE-2050A well. The MIDDLE-2050 well is located 32 ft southwest of the MIDDLE-2050A location shown in Figure 2. Details concerning the MIDDLE-2050 well are discussed below.

A. Project Name:

Drilling, Coring, and Installation of Wells MIDDLE-2050 and MIDDLE-2051 at the INL

B. Well Number:

MIDDLE-2050

C. Hole Location:

Approximately ¾ mi west of INTEC

D. Implementation Plans:

Specifications: "Drilling, Coring, and Installation of Wells MIDDLE-2050 and MIDDLE-2051 at the INL" (SPC-631)

Field Sampling Plan for the Waste Area Group 10 Deep Coreholes MIDDLE-2050 and MIDDLE-2051 (ICP 2005)

E. Logbooks:

Environmental Restoration Department Record of Corehole, Logbook No. ER-056-2005, "WAG 10 Corehole Project (MIDDLE-2050, MIDDLE-2050A)"

Environmental Restoration Department Record of Corehole, Logbook No. ER-076-2005, "WAG 10 Corehole Project (MIDDLE-2050, MIDDLE-2050A)"

4.1.2 Drilling and Completion Observations

A. Drilling Company:

Major Drilling Company, Salt Lake City, UT

B. Field Superintendent:

Frank Hight and Shaun Fleming

C. Drillers:

Luis Rosario, Gary Jensen, and Dale Gordon (drillers); Hayes Jensen, Tony Andersen, Trevor Andersen, Joel Peck, and Tom Anderson (drillers' helpers)

D. Geologists:

Gary Oberhansley, Arden Bailey, and Erik Whitmore

E. Field Team Leader:

Lori Lopez, Troy Buxter, and Brett Davis

F. Drill Rig Type:

Foremost DR-24 and UDR-1500

G. Drill Bit Type:

1. 15-in. button bit with air hammer drilled from surface to 76 ft bls with a 17-in. casing cutting shoe advanced from surface to 54.5 ft bls

2. PQ core bit modified to 5.97-in. OD with 3.27-in. ID, cored from 76 to 385 ft bls, Number 5A 3024 20-419-092

H. Drilling Activity:

Two crews of one driller and two helpers began work on this corehole on May 24, 2005. The subcontractor's drilling supervisor provided the technical needs for the drilling, coring, and troubleshooting for the project. Two field geologists were assigned to provide drilling oversight, logging, sampling, and assisted in completion of this well. Two field team leaders/subcontractor technical representatives oversaw and coordinated all aspects of this project. The health and safety officers (HSOs) and industrial hygienists (IHs) also were assigned to oversee all health and safety aspects of the drilling program. This corehole began with a day and night shift working 12 hours per day, 5 days a week.

Work began with setting up equipment at the drill site that had previously been graveled for surface stability during the spring thaw and summer rains. Drilling began on the same day with advancing a 16-in. surface casing through surface soils and alluvial gravels, using the DR (Foremost DR-24) drilling rig. This method of drilling was used to advance casing through unstable surface sediments prior to coring. Drilling ended the following day on May 25, 2005.

The borehole was drilled to 76 ft bls using a 15-in. carbide button bit and down-hole air hammer. One auxiliary air compressor (Sullair 900XH) was used during the initial drilling. Temporary 16-in. casing with a 1-ft-long, 17-in. carbide button cutting shoe was advanced to a depth of 54.5 ft bls while drilling. This depth was based on the top of the basalt located at 54 ft bls. Cuttings were routed through the drill string to the surface through a discharge hose. The cuttings were collected and examined there. Permanent 12-3/4-in. casing was then placed in the borehole to 76 ft bls. Cement grouted was added to the base of the casing along the annulus and inside the casing from 70 to 76 ft bls for sealing and stabilizing the bottom of the casing in the well bore. The 16-in. DR casing, with the cutting shoe, was removed from the borehole, while bentonite was poured between the 12-3/4-in. casing and the annulus for a seal. Early the following morning, the Foremost DR-24 drill rig was removed from the borehole. The UDR-1500 core rig and all supporting equipment were moved onto the corehole that afternoon, and the bentonite seal was finished being poured to the surface between the borehole annulus and the 12-3/4-in. casing late that evening. Note: The water meter at the Fire Station well was at 261,000 gal before coring began.

The setup of the core rig and equipment was finished very early the next morning on May 27, 2005, and coring began at 70 ft bls in cement inside the 12-3/4-in. casing. The core rods were 19.7-ft-long 134 (PQ) core rods attached to a sub, stabilizer reamer (6-in. OD), 10-ft-long core barrel, and a modified PQ core bit. The core bit was oversized from the standard 5.45-in. OD to a 5.98-in. OD bit, both cutting a 3-1/4-in. core. Water was injected into the corehole with 1 cup of Quik-Foam to every 500 gal of water. The meter at the Fire Station well was at 261,200 gal when the water truck began hauling water to the core site. Cement was cored from approximately 70 to 76 ft bls.

Coring was done in intervals varying in footage of up to 10-ft runs. The core was retrieved using a wire line overshot, which recovered an inner core barrel while the core string was disconnected from the top swivel drive. The core was pushed from the inner barrel between two pipes and placed into plastic core boxes holding up to 10 ft of the core. The core was then measured and examined with all observations made pertaining to the core and coring procedure recorded in a Record of Corehole logbook. Coring continued in basalt to 90 ft bls that morning, ending at the night shift, and stopping for the weekend.

The following Tuesday, May 31, 2005, coring continued to 214.5 ft bls, where the inner core barrel became stuck inside the outer barrel due to loose interbed silts and sands. The core string was tripped out of the corehole, the core was recovered, and coring continued early the next morning on June 1, 2005. Coring continued that day and the following morning with only weather-related delays to 385 ft bls. After the core had been retrieved and another run started, circulation was lost and the core bit and barrel became stuck with only 2 ft of up and down movement and no rotation. After rotation was established, the core string was back reamed to approximately 290 ft bls. At this depth, back reaming stopped for rig service on the hydraulics system. Later that evening, an auxiliary air compressor was used in an attempt to help circulation and to plow sloughing fines (loose silty, sandy interbed) out of the corehole. This was unsuccessful and work ended for the weekend.

The following Monday, June 6, 2005, an air hammer and bit, using the auxiliary compressor, was placed on top of the core string at the surface in an attempt to hammer the core string down hole to loosen it up. There was no movement so it was replaced with a heavier reverse-air hammer. The core string still had no movement. Early the next morning, HQ rods with an end plate were tripped inside the stuck core string to tap directly on the core bit in an attempt to loosen it inside the corehole. This also was not successful and the decision was made to abandon the corehole and offset it with a new corehole. The water meter at the Fire Station well was at 348,000 gal at the end of this corehole. Total water used for this corehole was 86,800 gal.

I. Summary of Well Construction Procedures:

On Monday, June 13, 2005, a cutter attached to HQ rods was tripped inside the 134 rods in an attempt to cut the 134 rods at 275 ft bls. The first attempt failed and the cutting tool and HQ rods were tripped out of the hole to replace the cutting tool. An onsite down-hole camera was ran into the 134 rods, where the stuck core bit was observed at 295.5 ft bls and the attempted cut inside the 134 rods was at 274.5 ft bls. The new cutters were sent down hole inside the 134 rods at the same depth, 274.5 ft bls, and the 134 rods were re-cut. The HQ rods and cutters were tripped out of the hole followed by removing the cut section of 134 (PQ) rods from the corehole late that night. The 14-ft section of core bit, core barrel, reamer and sub, and 7 ft of cut 134 (PQ) rods were left in the corehole between 295.5 and 274.5 ft bls.

The inner core barrel had been retrieved so that when the corehole was plugged and abandoned on July 5, 2005, bentonite fell freely through the core rod, barrel, and bit to the bottom of the corehole. Bentonite was poured to 2 ft bls that day. On September 27, 2005, a 2-ft cap of concrete was poured inside the 12-3/4-in. casing that had been cut flush to ground level.

J. Problems Encountered and Lessons Learned:

No significant problems had occurred, both mechanically and drilling/coring related, while drilling and coring this location until the depth cored at 385 ft bls. At this depth, the driller could not re-establish circulation down hole. The core bit and barrel became struck at that point. The core string was back reamed at 294.5 ft bls, where it became rock locked in the corehole with no rotation and up and down movement. Other methods previously mentioned did not loosen the stuck core bit, barrel, and rod.

It was determined that sloughing of silty sands from any or all of the interbeds—encountered between 118 to 122.5 ft bls, 160.8 to 167 ft bls, 215 to 224 ft bls (inferred), and 296.5 to 297 ft bls—resulted in the stuck core string at 385 ft bls and the rock locking at 2,954.5 ft bls. Once the decision to abandon the corehole was made, it was also decided to offset it with a new corehole drilled conventionally to 420 ft bls and cased at that depth to stabilize that section of the borehole before coring. This interval also caused coring problems in the first corehole, MIDDLE-2051.

K. Instruments Installed in the Borehole:

No instruments were installed in this corehole because of the shallow depth at which the core string had become stuck and coring stopped. The corehole was abandoned in accordance with state regulations.

4.1.3 Drawings

A. Location Maps:

See Figure 2.

B. As-Built Drawings:

See Appendix C.

4.2 MIDDLE-2050A End of Core Report

4.2.1 General

The MIDDLE-2050A well was drilled and cored as a replacement for the abandoned MIDDLE-2050. Drilling and coring of MIDDLE-2050A was initiated on June 6, 2005. Drilling was conducted to a depth of 420 ft and a 6-5/8-in. casing was installed. Coring was then conducted to a depth of 1,333 ft bls. An interbed, located at 1,280 ft bls, created coring difficulties and sloughing. A tricone bit was used to ream the hole from 1,236 ft to 1,333 ft. Drilling was continued with the tricone to a depth of 1,417 ft bls. Coring was then continued to the total depth of 1,427.4 ft. The well was then completed with a Westbay MP55 System™ with five monitoring zones. Details concerning the drilling and installation of the Westbay MP55 System™ are discussed below.

A. Project Name:

Drilling, Coring, and Installation of Wells MIDDLE-2050 and MIDDLE-2051 at the INL

B. Well Number:

MIDDLE-2050A

C. **Hole Location:**

Approximately ¾ mi west of INTEC, 32 ft NE of MIDDLE-2050

D. **Implementation Plans:**

Specifications: "Drilling, Coring, and Installation of Wells MIDDLE-2050 and MIDDLE-2051 at the INL" (SPC-631)

Field Sampling Plan for the Waste Area Group 10 Deep Coreholes MIDDLE-2050 and MIDDLE-2051 (ICP 2005)

E. **Logbooks:**

Environmental Restoration Department Record of Corehole, Logbook No. ER-056-2005, "WAG 10 Corehole Project (MIDDLE-2050, MIDDLE-2050A)"

Environmental Restoration Department Record of Corehole, Logbook No. ER-076-2005, "WAG 10 Corehole Project (MIDDLE-2050, MIDDLE-2050A)"

Environmental Operations Sample Logbook, Logbook No. ER-007-2005, "WAG 10 Corehole Project (MIDDLE-2051, MIDDLE-2050A)"

4.2.2 Drilling and Completion Observations

A. **Drilling Company:**

Major Drilling Company, Salt Lake City, UT

B. **Field Superintendent:**

Frank Hight and Shaun Fleming

C. **Drillers:**

Luis Rosario, Gary Jensen, and Dale Gordon (drillers); Hayes Jensen, Tony Andersen, Trevor Andersen, Joel Peck, and Tom Anderson (drillers' helpers)

D. **Geologists:**

Gary Oberhansley, Arden Bailey, and Erik Whitmore

E. **Field Team Leader:**

Lori Lopez, Troy Buxter, and Brett Davis

F. **Drill Rig Type:**

Foremost DR-24 and UDR-1500

G. **Drill Bit Type:**

1. 15-in. button bit with air hammer drilled from surface to 71 ft bls with 17-in. casing cutting shoe advanced from surface to 55.5 ft bls

2. 13-in. button bit with air hammer drilled from 71 to 420 ft bls

3. PQ core bit modified to 5.97-in. OD with 3.27-in. ID, cored from 420 to 926 ft bls, Number 5A 3023 20-419-092

4. PQ core bit modified to 5.97-in. OD with 3.27-in. ID, cored from 926 to 1,094 ft bls, Number 5A 3021 20-419-091

5. PQ core bit modified to 5.97-in. OD with 3.27-in. ID, cored from 1,096 to 1,236 ft bls, Number 5A 3022 20-419-091

6. PQ core bit 5.45-in. OD with 3.27-in. ID, cored from 1,236 to 1,285 ft bls, 134T CHD S8

7. PQ core bit 5.45-in. OD with 3.27-in. ID, cored from 1,284 ft bls (includes 1 ft of clay fill) to 1,333 ft bls, 134T, Number 2A 1831

8. 5-7/8-in. tricone reamed from 1,236 to 1,333 ft bls, drilled from 1,333 to 1,417 ft bls

9. PQ core bit 5.45-in. OD with 3.27-in. ID, cored from 1,417 to 1,427.4 ft bls, 134T, Number 2A 1831

10. 5-3/4-in. tricone washed from approximately 1,327 to 1,417 ft bls and reamed from 1,417 to 1,427.4 ft bls

11. 3-5/8-in. tricone washed from 1,326 to 1,406.5 ft bls

12. 5-3/4-in. tricone washed from 1,384 to 1,422 ft bls.

H. Drilling Activity:

Two crews of one driller and two helpers began work on this corehole on June 7, 2005. The subcontractor's drilling supervisor provided the technical needs for the drilling, coring, and troubleshooting for the project. Two field geologists were assigned to provide drilling oversight, logging, and sampling, and they assisted in completion of this well. Two field team leaders/subcontractor technical representatives oversaw and coordinated all aspects of this project. The HSOs and IHs also were assigned to oversee all health and safety aspects of the drilling program. This corehole began with a day and night shift working 12 hours per day, 5 days a week.

Work began on the same day with surveying the new offset location for buried ordnance and staking the new corehole (MIDDLE-2050A) approximately 32 ft N 25°E of the original MIDDLE-2050 corehole location, which had been drilled, cored, and abandoned. The Foremost DR-24 drill rig was set up on the new location and the following day drilling began with advancing 16-in. surface casing into surface soils and alluvial gravels, using the DR drilling rig. This method of drilling was used to advance casing through unstable surface sediments prior to coring.

The borehole was drilled to 71 ft bls using a 15-in. carbide button bit and down-hole air hammer. One auxiliary air compressor (Sullair 900XH) was used during the initial drilling. Temporary 16-in. casing with a 1-ft-long, 17-in. carbide button cutting shoe was advanced to a depth of 55.5 ft bls while drilling. This depth was based on the top of the basalt located at 54 ft bls. The 15-in. button bit was replaced with a 13-in. button bit and drilling with the down-hole air hammer continued to a depth of 420 ft bls on June 9, 2005. Cuttings were routed through the drill string to the surface through a discharge hose. The cuttings were collected and examined there.

That afternoon, the drill string was tripped for the borehole and the USGS video logged the borehole, followed with a caliper and natural gamma log run. On Tuesday, June 14, 2005, the 6-5/8-in. casing was tripped into the borehole to 420 ft bls and bentonite was used to seal the annulus and to stabilize the casing. The Foremost DR-24 drill rig was then moved off the borehole and the UDR-1500 core rig was moved onto the borehole.

Coring began that evening at 420 ft bls in the basalt. Water, with 1 cup of Quik-Foam to 500 gal, was pumped down the corehole for bit cooling and coring stability. The meter at the Fire Station well read 348,000 gal at the beginning of this corehole. Coring continued with only minor mechanical problems the rest of that week until June 17, 2005, at a depth of 914 ft bls.

The following Monday, June 20, 2005, coring continued at 914 to 926 ft bls, where the core string began to increase in torque. The core string was tripped out of the corehole and the core bit was replaced. The core string was tripped back into the hole and coring continued the next 2 days to 1,096 ft bls, where the core barrel jammed and was tripped out of the hole. The core section was recovered and a new core bit was put on and tripped back into the corehole. Coring continued at 1,096 ft bls on the morning of June 22, 2005, with only a few short delays due to lightning. The following evening, the core string was tripped from the corehole at 1,236 ft bls for a new core bit. The core bits at this point were of the standard size of 5.45 in. OD. A new reamer also was used at this point being 5.5 in. OD. The bit was replaced and the core string was tripped back in the hole and cored to 1,251 ft bls, where coring ended for the weekend.

On Monday, June 27, 2005, the core bit became plugged as coring began at 1,251 ft bls. In an attempt to retrieve the inner core barrel, the wire line broke so the core string was tripped out of the hole. The bit was cleaned and tripped back into the corehole and coring continued to 1,272.5 ft bls, where the bit became plugged. Again, the wire line broke in an attempt to recover the inner core barrel and the core string was tripped from the hole to clean out the plugged bit. The core string was tripped back into the hole and coring resumed at 1,272.5 ft bls very early the next day to a depth of 1,285 ft bls, where the bit became plugged. The core string was tripped out of the hole and the bit was cleaned. The silty clay interbed being cored kept plugging the core bit around the cutting shoe. The core string was tripped back down the hole to 1,283 ft bls for another attempted core run and became plugged at 1,284 ft bls. The inner core barrel was retrieved, in an attempt to unplug the core bit, with no core recovered. It was returned back down hole and coring at 1,284 ft bls was again resumed. The bit immediately plugged again so the core string was tripped out of the hole and a different core bit, with water jet ports along the cutting face, was used to replace the previous bit.

That afternoon (June 28, 2005), the new core bit was tripped into the corehole and coring began at 1,284 ft bls and continued to 1,320 ft bls, where the inner core barrel became stuck. Just after midnight, that next morning, the core string was tripped out of the hole and the core barrel was cleaned of stuck silty clay interbed. The core string was returned back down the corehole to approximately 1,300 ft bls, where sloughing clay was encountered and re-cored to 1,322 ft bls the following morning. The inner core barrel was retrieved with no recovery. Coring continued to 1,333 ft bls, where the wire line broke while retrieving the inner core barrel. The core string was tripped back out of the hole and the inner barrel with a small amount of silty clay interbed was recovered. That evening, the decision was made to conventionally drill the remaining interbed with a 5-7/8-in. tricone. The tricone was placed on the 134 rods and tripped in the corehole to approximately 1,236 ft bls, where it reamed the corehole to 1,333 ft bls and began drilling the new hole at that depth. No cuttings were recovered, being lost in the fractured basalt intervals above the interbed.

Drilling continued that next day (June 30, 2005) to a depth of 1,417 ft bls, where it was determined that the bit might be drilling basalt. The drill string was tripped out of the corehole/borehole. Before going back into the hole with the core bit and barrel, the main wire line used to trip the core string was replaced early that next morning on July 1, 2005, and the core string was tripped into the hole. Coring began at 1,417 ft bls and ended at 1,427.4 ft bls, where recovered basalt appeared to have mineral alteration with fracture and pore spaces filled with calcite. The thick interbed that had been cored and drilled appeared to have been at the base of the aquifer. The decision was made to stop coring at that depth; the core string was tripped up hole into the 6-5/8-in. casing and work stopped for the weekend.

I. Summary of Well Construction Procedures:

On July 5, 2005, the night crew shift was ended. The USGS video logged the corehole through the core string and 6-5/8-in. casing at 420 ft bls and open hole to 1,151 ft bls where the water became too murky for visual clarity. The water was encountered at 480 ft bls in this video. The temperature log, resistivity log, and natural gamma/caliper log also were run in the corehole to approximately 1,280 ft bls. Later that evening, the core string was run back down the hole to approximately 1,412 ft bls, where the interbed sloughing was encountered. The neutron and gamma/gamma log was then run inside the core string to 1,350 ft bls, where interbed material had entered and plugged the inside of the 134 rods and core barrel. The USGS finished the log run and the core string was tripped out of the corehole. The core barrel and bit were replaced with a 5-3/4-in. tricone bit and the corehole was washed from approximately 1,327 to 1,417 ft bls and reamed from 1,417 to 1,427.4 ft bls. The following day, the USGS ran the neutron and gamma/gamma log inside the 134 rods.

The corehole was purged and developed from July 7 to July 20, 2005, using a down-hole pump/motor and packers. Water samples were taken at each interval developed. See the field Sample Logbook ER-007-2005 (pp. 1–29) for more details. Information pertaining to pump specifications, intervals of well development, water clarity, and volumes pumped for both wells can be found in Appendix B under “Well Development.”

On July 20, 2005, the pump and packer string was lowered down hole from the last interval of purging and sampling at 494 to 539 ft bls. A lower interval of interest at 661 to 706 ft bls had been planned later for sampling. After lowering the pump and packer string about 40 ft, an obstruction was encountered and the pump and packer assembly became stuck down hole. While pulling on the tremie pipe and stainless-steel riser pipe used for the down-hole pump, the coupler holding the riser pipe on the landing plate at the surface broke and the riser pipe and pump fell another 31 to 34 ft.

The following day, the sections of stainless-steel pipe down hole were removed from the corehole and the remaining steel tremie pipe was connected using a fishing tool. Water was pumped down the corehole in an attempt to loosen rock or sediment between the two packers stuck in the corehole. The packers were stuck at 564 to 609 ft bls. Later that day, while pulling on the stuck pump and packer string, the tremie pipe parted just above the top packer. The tremie pipe was then removed from the corehole and the packers and pump remained stuck in the hole.

On Monday, July 25, 2005, both the MIDDLE 2050 and MIDDLE 2050A core were surveyed by a radiological engineer (radiological control technician) and the core was delivered to the USGS Core Library. The pump and packer assembly was recovered using a down-hole fishing tool. The stacked 134 drill rods removed from the rigs derrick and the UDR-1500 drill/core rig were moved off location. On July 27, 2005, the Foremost DR-24 drill rig was moved onto the corehole and 12-3/4-in. casing was ran into the corehole to 71 ft bls while the 16-in. DR casing was removed from the borehole. Bentonite was used as a seal between the casing and the annulus.

On August 22, 2005, the Foremost DR-24 rig and equipment were moved on location and the following day the 134 drill rods were tripped back into the corehole to clean to the bottom in preparation for the Westbay packer installation. The 134 rods were open ended with a bottom shoe that was tripped to 1,335 ft bls, where an obstruction was encountered (sloughing interbed). The next day, a 3-5/8-in. tricone bit on NQ and HQ rods was tripped down hole inside the 134 rods to 1,326 ft bls. The following day, the 3-5/8-in. tricone washed to 1,406.5 ft bls. With the drill string in the hole, the USGS returned and ran the gyro deviation log and work ended for the weekend.

On Monday, August 29, 2005, the HQ drill rods attached to the NQ drill rods and 3-5/8-in. tricone bit were tripped out of the corehole. The 134 rods were kept in the hole for borehole stability. The following day, the 134 rods were tripped out of the corehole and the DR rig was moved off location.

On Tuesday, September 6, 2005, the USGS video logged the corehole to 1,277 ft bls, where a bridge was encountered. Several pieces of 1/4-in. poly tube used to inflate the packers also were observed from 589 to 740 ft bls. The camera was removed from the corehole. The following day, a boom truck was used to remove three of the longer sections of tubing, using a fishing tool at the end of the wire line. The boom truck was moved off location and the 6-5/8-in. casing at the surface was modified in preparation for the Westbay installation.

On Monday, September 12, 2005, the Foremost DR-24 drill rig was moved back on location and the 134 (PQ) rods with the end shoe were tripped back into the hole to clean out the corehole. The 134 rods were tripped to a total depth of 1,375 ft bls (about 5 ft from the bottom of the interbed), where a bridge was encountered. The next day, the HQ rods with a 5-3/4-in. tricone bit were tripped in the hole inside the 134 rods washing and reaming to 1,384 ft bls. Washing and reaming continued the following day to approximately 1,422 ft bls and 200 ft of NQ rods were tripped out of the corehole. The next day, September 15, 2005, the rest of the NQ and HQ drill rods and the 5-3/4-in. tricone bit were tripped out of the hole. The USGS ran the natural gamma and caliper log through the open hole and tagged the bottom of the hole at 1,418.7 ft bls. The caliper log showed that a new borehole might have been drilled below the interbed from the top of the basalt at 1,378 ft bls to a total depth drilled at 1,422 ft bls. The decision was made to run the Westbay end pipe to the base of the interbed because of the smaller hole size. To fill the bottom of the borehole, six bags of 6X9 sand used for filter pack were poured down hole inside the 134 rods. The bottom of the hole was tagged at 1,379 ft bls using the caliper tool from the USGS. The logging tool was removed and installation of the

Westbay Packer System commenced. The meter at the Fire Station well at the end of this corehole read 569,200 gal of water. The total amount of water used at this corehole was 260,700 gal. The total amount of water used for this project was 568,700 gal. Surface completion on the wellhead was finished on September 27, 2005.

J. Problems Encountered and Lessons Learned:

To avoid the problems encountered in both the MIDDLE-2051 and MIDDLE-2050 corehole, this corehole was drilled conventionally to a depth of 420 ft bls with 6-5/8-in. casing installed for borehole stability. Coring went reasonably well until the thick interbed at 1,280 ft bls was encountered. After coring to 1,333 ft bls with much difficulty and little recovery, conventional drilling using a 10-3/4-in. button bit air hammer was used to a depth of 1,417 ft bls. From there, coring continued to 1,427.4 ft bls.

A dual-straddle packer had become stuck in the corehole because of sloughing rocks or interbed material from the annulus. This resulted in fishing out the packers and pump. The packer interval might have been too far apart for the strength of the riser pipe used.

The 98-ft-thick lower interbed kept sloughing in bridging off the corehole. Multiple runs with the drill string were made to clean out the corehole for logging and Westbay installation. The last washing and reaming to open the corehole below the interbed resulted in the possible drilling of a new hole from somewhere near the top of the basalt, base of the interbed, to 1,422 ft bls. Because of the smaller borehole and because of the unstable nature of the borehole, the bottom of the Westbay Packer System was placed at the bottom of the interbed through the 134 rods at a depth of 1,379 ft bls.

K. Instruments Installed in the Borehole:

See Westbay's (Schlumberger) Completion Report found in Appendix C.

4.2.3 Drawings

A. Location Maps:

See Figure 2.

B. As-Built Drawings:

See Appendix C.

4.3 MIDDLE-2051 End of Core Report

4.3.1 General

Drilling of the MIDDLE-2051 well was initiated on January 18, 2005. Drilling was conducted to a depth of 127 ft bls, which was achieved on January 31, 2005. Coring was initiated on March 23, 2005. Coring was conducted to 491 ft bls. Sloughing interbed caused coring difficulties and the hole was over reamed to allow the installation of a 6-5/8-in. casing to be installed to a depth of 430 ft. After installation of the casing, the coring was continued until May 18, 2005, when the total depth of 1,179 ft bls was reached.

Several problems were encountered during the drilling and coring of MIDDLE-2051. The temporary 16-in. casing became rock locked or stuck by the basalt located at 107 ft bls. The casing was abandoned in place. Additionally, during the installation of the 6-5/8-in. casing, the use of a 5-7/8-in. tricone bit was used to help install the casing through the sloughed material and to ream the borehole back to the cored depth of 491 ft. The sloughing materials locked the tricone and caused the drill rods and the 6-5/8-in. casing to part. The drill rods and bit were eventually retrieved using various retrieval or fishing tools. The 6-5/8-in. casing was aligned and grout was poured into the annulus and allowed to fill the interior of the casing to a level above the separation. Coring was then continued through the grout to the total depth. The well was then completed with a Westbay MP55 System™ with five monitoring zones. Details concerning the drilling and installation of the Westbay MP55 System™ are discussed below.

A. Project Name:

Drilling, Coring, and Installation of Wells MIDDLE-2050 and MIDDLE-2051 at the INL

B. Well Number:

MIDDLE-2051

C. Hole Location:

Approximately 2-3/4 mi NE of RWMC, south of the Big Lost River

D. Implementation Plans:

Specifications: "Drilling, Coring, and Installation of Wells MIDDLE-2050 and MIDDLE-2051 at the INL" (SPC-631)

Field Sampling Plan for the Waste Area Group 10 Deep Coreholes MIDDLE-2050 and MIDDLE-2051 (ICP 2005)

E. Logbooks:

Environmental Restoration Department Record of Corehole, Logbook No. ER-011-2005, "WAG 10 Corehole Project (MIDDLE-2051)"

Environmental Restoration Department Record of Corehole, Logbook No. ER-010-2005, "WAG 10 Corehole Project (MIDDLE-2051)"

Environmental Operations Sample Logbook, Logbook No. ER-007-2005, "WAG 10 Corehole Project (MIDDLE-2051, MIDDLE-2050A)"

4.3.2 Drilling and Completion Observations

A. Drilling Company:

Major Drilling Company, Salt Lake City, UT

B. Field Superintendent:

Frank Hight and Shaun Fleming

C. Drillers:

Luis Rosario, Gary Jensen, and Dale Gordon (drillers); Chris Hight, Hayes Jensen, Tony Andersen, Trevor Andersen, Joel Peck, and Tom Anderson (drillers' helpers)

D. Geologists:

Gary Oberhansley, Arden Bailey, and Erik Whitmore

E. Field Team Leader:

Lori Lopez, Troy Buxter, and Brett Davis

F. Drill Rig Type:

Foremost DR-24 and UDR-1500

G. Drill Bit Type:

1. 15-in. button bit with air hammer drilled from surface to 127 ft bls with 17-in. casing cutting shoe advanced from surface to 107 ft bls

2. PQ (134-mm) core bit modified to 5.97-in. OD with 3.27-in. ID, cored from 127 to 179 ft bls, Number 5A 2311

3. PQ core bit modified to 5.97-in. OD with 3.27-in. ID, cored from 179 to 380.4 ft bls, Number 5A 2312

4. PQ core bit modified to 5.97-in. OD with 3.27-in. ID, cored from 380.4 to 453 ft bls, Number 5A 2314

5. PQ core bit modified to 5.97-in. OD with 3.27-in. ID, cored from 453 to 468 ft bls, Number 5A 2313 20-411-581

6. PQ core bit modified to 5.97-in. OD with 3.27-in. ID, cored from 468 to 487 ft bls, Number 5A 2447 20-419-074

7. PQ core bit modified to 5.97-in. OD with 3.27-in. ID, cored from 487 to 491 ft bls, Number 5A 2447 20-419-074

8. 10-3/4-in. button bit with air hammer reamed from 91 to 378 ft bls

9. 10-3/4-in. button bit with air hammer reamed from 378 to 430 ft bls

10. 5-7/8-in. tricone reamed from 390 to 441.2 ft bls

11. PQ core bit modified to 5.97-in. OD with 3.27-in. ID, cored from 389.5 to 492 ft bls, Number 5A 2449 20-419-091

12. PQ core bit modified to 5.97-in. OD with 3.27-in. ID, cored from 492 to 928 ft bls, Number 5A 2459 20-419-092

13. PQ core bit modified to 5.97-in. OD with 3.27-in. ID, cored from 928 to 1,129 ft bls, Number 5A 2450 20-419-092

14. PQ core bit modified to 5.97-in. OD with 3.27-in. ID, cored from 1,129 to 1,179 ft bls, Number 5A 3024 20-419-092.

H. Drilling Activity:

A crew of one driller and two helpers began work on this corehole on January 18, 2005. The subcontractor's drilling supervisor provided the technical needs for the drilling, coring, and troubleshooting for the project. A field geologist was assigned to provide drilling oversight, logging, sampling, and assistance in completion of this well. A field team leader/subcontractor technical representative oversaw and coordinated all aspects of this project. The HSOs and IHs also were assigned to oversee all health and safety aspects of the drilling program. The project began with day shift only with 10-hour work days, 5 days a week. After the coring began and when Major's other crewmembers became available, a second night crew of one driller and two helpers were added, and the work schedule changed to 12-hour shifts at 5 days a week.

Work began with setting up equipment at the drill site that had previously been graveled for surface stability during winter, spring thaw, and summer rains. A soil barrier also was placed between the drill/core site and the adjoining Big Lost River drainage to help confine drill cuttings and fluids. The following day, drilling began with advancing 16-in. surface casing through surface soils and alluvial gravels, using the DR (Foremost DR-24) drilling rig. This method of drilling was used to advance casing through unstable surface sediments prior to coring. Drilling continued until January 26, 2005.

The borehole was drilled to 127 ft bls using a 15-in. carbide button bit and down-hole air hammer. One auxiliary air compressor (Sullair 900XH) was used during the initial drilling. Temporary 16-in. casing with a 1-ft-long, 16.5-in. carbide button cutting shoe was advanced to a depth of 107 ft bls while drilling. This depth was based on geological discretion. Cuttings were routed through the drill string to the surface through a discharge hose. The cuttings were collected and examined there. Permanent 12-3/4-in. casing was then placed in the borehole to the total depth drilled. Cement grouted was placed at the base of the casing along the annulus and inside the casing for sealing and stabilizing the bottom of the casing in the well bore.

Before removing the temporary 16-in. casing, it was discovered that a large open void had developed just under the frozen surface soil, along the borehole wall and 16-in. casing. A funnel-shaped void had been produced as loose sand and gravels began caving down the annulus to the bottom of the borehole around the air hammer and bit. The cavings were blown from the borehole by the compressed air used to remove drill cuttings from the bit contact in the borehole. To avoid surface caving along the outside of the 16-in. casing behind the drill rig, bentonite was poured into the void to keep the drill rig stable while pulling the temporary 16-in. casing out of the borehole.

The drillers were unable to remove the 16-in. temporary casing from the borehole. It had become stuck in the basalt interval down hole (rock locked). Attempts to loosen the stuck casing were made by using the air hammer at the surface to hammer on the stuck casing to jar it loose and by using the casing drive to rotate the casing to loosen it down hole. Both attempts failed. With the cement grout inside and between the 12-3/4-in. and 16-in. casings, rotation of the 16-in. casing caused both casing strings to rotate. To keep the

12-3/4-in. casing from parting down hole, the decision was made to leave the 16-in. casing in the borehole. On January 31, 2005, the Foremost DR-24 drill rig and all equipment and supplies were removed from the drill site.

On March 23, 2005, the UDR-1500 core rig and all supporting equipment were moved onto the corehole. The following day, the drillers installed a new pump at INL's Fire Station well along Lincoln Avenue, north of INTEC. The water from that well would be used in this coring project. A meter gauge was placed on the wellhead to monitor the volume of water used for injection while coring, beginning at 500 gal. A water truck was used to haul the water to the core site. The setup of the core rig and equipment was finished that morning and coring began inside the 12-3/4-in. casing using 19.7-ft-long 134 (PQ) core rods attached to a sub, stabilizer reamer (6-in. OD), 10-ft-long core barred, and a modified PQ core bit. The core bit was oversized from the standard 5.45-in. OD to 5.98-in. OD bit, both cutting a 3-1/4-in. core. Water was injected into the corehole with 1 cup of Quik-Foam to every 500 gal of water. Cement was cored from approximately 92 to 102 ft bls that day.

The following Monday, March 28, 2005, the remaining cement was cored to 126.7 ft bls where basalt was encountered. Coring from there was done in intervals, varying in footage of up to 10-ft runs. The core was retrieved using a wire line overshot, which recovered an inner core barrel while the core string was disconnected from the top swivel drive. Split stainless-steel sleeves placed inside the inner 10-ft core barrel were initially used to help keep the core undisturbed while the core was pushed out of the inner barrel using water pressure. The core was pushed from the inner barrel between two pipes and placed into plastic core boxes holding up to 10 ft of core. The core was then measured and examined with all observations made pertaining to the core and coring procedure recorded in a Record of Corehole logbook. Coring continued in basalt and sediment interbeds to 169 ft bls that day with no major problems.

Coring continued the following day to 175 ft bls, where the bit stopped coring. The inner core barrel also was stuck inside the outer barrel; thus, the core string was tripped out of the corehole and the core was recovered. Half of the core bit's diamond inset cutting surface was missing. The bit was replaced and coring continued to 204 ft bls that day. A trailer was moved onto the core site for an office and shelter, and more gravel was placed on the surface core pad.

Coring continued to 331.5 ft bls for the next 2 days, where again the core bit stopped coring and the inner barrel became stuck. The core string was again tripped out of the corehole and the core was recovered. The core bit was very worn on the outside and inside of the cutting face. This made the core that was being cut too big for the inner stainless-steel split slips. The drill string was tripped back into the corehole and coring continued to 381 ft bls, where the core bit stopped coring. The inner core barrel was recovered. The following workday, April 4, 2005, the core string was tripped out of hole. The core bit showed much wear and was replaced.

The core string and the new bit were tripped back into the corehole and coring continued until the following day to 451 ft bls, where again the bit wore out and needed to be replaced. Two sections of the cutting face had broken off. A new bit was tripped back into the corehole and coring continued to 463 ft bls when the inner core barrel jammed inside the core barrel. The core string was tripped out of the hole and the locking couplers on the inner barrel along with the sub were stabilized and replaced; the core string was tripped back into the hole. At 468 ft bls, the coring stopped and the core string was tripped out of the hole. All of the cutting face on the core bit had been worn off. Coring was stopped until a new bit was delivered.

On April 7, 2005, a new bit was tripped into the corehole and coring continued to 479 ft bls. The core string was tripped out of the hole again because of poor coring conditions. The bit appeared to be ok. The latching couplers were replaced again and the core string was returned back in the corehole. The next core run was to 488 ft bls only. The core string was then tripped back out of the corehole and both the inner and outer core barrels were inspected to be ok. The inner core barrel slips (split stainless-steel sleeves) were removed because of the constant binding inside the inner barrel. The core string was then tripped back into the hole and coring continued to 490.5 ft bls. The core string then was partially tripped out of the hole for the weekend.

On the following Monday, the core string was returned to the bottom of the hole and coring was resumed with very poor penetration. The core string was tripped out of the hole again. The bit showed much wear on both the inside and outside of the cutting face. A new bit was put on and tripped back into the hole, and coring began by reaming and coring over about 4 ft of fill at the bottom to the corehole. Coring continued to about 491 ft bls, where the core barrel began to stick and became plugged. The core string was tripped partially out of the corehole until the inner core barrel was recovered and the core bit became unplugged. On returning the core string back into the hole, several obstructions and bridges were encountered and coring continued to approximately 450 ft bls, where the core bit stopped penetration. The core string was tripped out of the hole for the second time that day. The core bit had all of the diamond-impregnated tungsten cutting face worn off. The decision was made to ream the corehole with an 8-in. air hammer and a 10-3/4-in. button bit to the present depth cored (491 ft bls) and run 6-5/8-in. casing to stabilize the corehole and keep the interbeds already cored from sloughing back into the corehole. Later that day, drilling/reaming began at 91 ft bls in cement. The corehole was reamed to 119 ft bls that same day.

The following day, the drilling crew changed out the auxiliary air compressor and continued reaming the corehole to 278 ft bls. The borehole was conditioned and minor rig service was made before partially tripping the drill string out of the hole. The drill sting was tripped back down the hole the next day, but it became plugged before reaching the bottom of the borehole. The drill string was then tripped from the borehole to clean out the air hammer and bit. The drill string was tripped back down the borehole and washing and reaming continued to approximately 250 ft bls, where the air hammer stopped firing. Water that was encountered at 221.5 ft bls had been blown from the borehole while drilling and contained at the surface a pound near the drill rig. The drill string was tripped back out of the borehole, which required back reaming at first. The next day, the spring in the foot valve in the air hammer was replaced and the drill string was tripped back into the borehole. Reaming continued to 345 ft bls when the work day was finished, and the drill string was partially tripped out of the borehole.

When the drill string was tripped back down the hole, the hammer would not fire the next day. The drill string was tripped once more from the borehole and the hammer was replaced. The drill string was tripped back down the borehole and washing and reaming continued to 378 ft bls, where the drill string was again partially tripped out of the borehole for the weekend. While tripping out of the hole, the drill string pulled very tight and had to be back reamed while coming out. At 340 ft bls, the top head swivel drive went out. On Tuesday, April 19, 2005, the parts for the top head came in and the drill rig was repaired. Back reaming out of the borehole continued to approximately 300 ft bls.

The drillers started a night crew this day. The drilling and coring on this location now were on a 24-hour-a-day schedule. The night crew worked on rig hydraulic and cable repair and then continued to back ream out of the borehole. The next morning, back reaming was stopped and the main wheel on the cable line and the cable were replaced. Back reaming continued late that night and all of the next day.

The following day, the borehole was back reamed to 278 ft bls, where it became very difficult to continue. Steel tremie pipe was tripped in the borehole alongside the drill rods to 250 ft bls and air was injected using an auxiliary air compressor. This discharged muddy foam to the surface. Water was added to the borehole and airlifting continued with red silty interbed material to the surface until the tremie pipe reached 265 ft bls. At this point, circulation had gotten back to the air hammer and the tremie pipe was tripped out of the borehole. Back reaming continued to 257.9 ft, where the drill string broke free and was tripped out of the borehole. A new button bit replaced the badly worn bit used for back reaming, and the drill string was tripped back into the borehole. The next morning, the bit and hammer were tripped in the hole to approximately 378 ft bls. The hammer would not fire and the drill string was tripped out of the borehole. The foot valve was replaced in the air hammer and the drill string then tripped back into the borehole. The corehole was then reamed to a total depth of 430 ft bls with the 10-3/4-in. button bit. The drill string was then tripped out of the borehole for down-hole logging by the USGS. Just before midnight, the geophysical logs (Caliper and Natural Gamma) were ran by the USGS.

Shortly after midnight (April 26, 2005), the 6-5/8-in. casing began to be run down the borehole. That morning, the casing was run to 389 ft bls, where it hit an obstruction. A down-hole camera run showed the bottom of the casing to be approximately 388 ft bls. After minor rig repair, a 5-7/8-in. tricone bit on HQ rods was tripped in the hole through the 6-5/8-in. casing. The tricone was used to wash and ream back down to 430 ft bls to help advance the casing. The 6-5/8-in. casing was set at 430 ft bls and the tricone bit was advanced to 441.2 ft bls. Drilling stopped to connect the diverter head to the casing at the surface. While doing this, the casing settled to 430.5 ft bls. It was then decided to remove a drill rod from the drilling string and hook onto the casing to see if it was going to settle any more. The drill string seemed to be very tight at that depth. The drillers began tripping the drill string out of the borehole in order to check the drill bit and to video log the borehole and to see the down-hole conditions. Only 330 ft of HQ drill rods was tripped out of the borehole; the remaining rods (about 110 ft) plus the sub and tricone had twisted off down hole. A down-hole camera run showed the 6-5/8-in. casing parted with about a 1-ft separation from the lower parted casing. The connection collar at 98 ft bls was bent in and damaged. The top of the twisted-off HQ rods was observed at 339 ft bls. The remaining night was spent removing the undamaged and parted 6-5/8-in. casing out of the hole and building a fishing tool to be placed on the HQ rods to remove the twisted-off drill string.

Early the next day, the first attempt to fish for the lost drill string out of the borehole was unsuccessful. The drillers replaced the spearing tool and spent the rest of the day trying to hook into the lost drill string. The fishing tool was tripped in and out of the borehole two more times with no success. The following evening, a cutter placed on NQ rods was tripped into the borehole in an attempt to cut off the stuck drill rods just above the tricone. The first attempt of cutting the rods at 429 ft bls was unsuccessful. The second attempt used a new cutter tool. The cutting tool was then tripped out of the borehole and the spear-fishing tool attached to NQ rods was tripped back into the borehole. On the morning of April 29, 2005, after two attempts, the cut-off portion of the lost drill string (approximately 100 ft) was removed from the borehole. Later that afternoon, a junk basket attached to NQ rods was tripped into the borehole to retrieve the remaining lost drill string (fish) in the hole, and a 4-ft section of damaged HQ rod was recovered. The 134 core rods and a bottom shoe were then tripped into the borehole inside the 6-5/8-in. casing to 429 ft bls. The bottom of the hole was then tagged inside the 134 rods at 431 ft bls. The bottom of the 6-5/8-in. casing was estimated to be located approximately 431 ft bls and the bit at 441 ft bls; washed and reamed to 431 ft bls to what appeared to be the top of the cut HQ rods.

The following Monday, May 2, 2005, a down-hole camera showed sand inside the bottom of the 6-5/8-in. casing. Washing and reaming over the HQ rods with the 134 drill rods continued to approximately 439.5 ft bls. The water and sediments/cuttings were blown out of the borehole until it blew dry. The down-hole camera was run back down the hole showing the top of the cut HQ rods (fish) at approximately 431 ft bls. A spear-fishing tool was then tripped into the borehole on NQ rods. The first attempt was unsuccessful and the tool was tripped out of the borehole. The grapple section of the spear was replaced and tripped back into the borehole. The spear was sent back down the borehole and stuck into the fish and held. The cut HQ rods and bit (fish) appeared to still be stuck with the drill rig pulling very hard on the drill string and fish. The 134 drill rods were used to continue washing and reaming over the fish to the top of the tricone bit (about 440 ft bls). At this point, the fish pulled free, but the tricone bit hung up on the bottom of the 6-5/8-in. casing. The 134 rods were then tripped out of the hole and the onsite down-hole camera was run inside the 6-5/8-in. casing. The camera showed the 6-5/8-in. offset on a basalt ledge (approximately 430.5 ft bls) with the tricone bit hitting the bottom of the casing shoe. It also showed that the casing was slightly parted at 392 ft bls. The camera was kept in the hole while pulling on the fish to observe the bit and offset casing. The fish broke away from the fishing tool and damaged the down-hole camera. The fishing tool was speared back into the fish without the guide of the down-hole camera. The drill string pulled free again and was tripped out of the borehole. It was assumed that the fish and spear parted again; however, just at the end of the dayshift, the cut HQ rods and bit (fish) were on the end of the fishing tool. That night, the tremie pipe was run down hole inside the 6-5/8-in. casing. Early the next day, the lower part of the casing, both inside and out, was cemented to approximately 390 ft bls. A casing spear had been used to lift the 6-5/8-in. casing up about 1 ft and then it was set back down to allow the cement grout to fill within the borehole annulus.

On May 4, 2005, the core barrel and bit were tripped back into the borehole to the top of the cement inside the 6-5/8-in. casing at 389.5 ft bls and the coring of a 6-in. corehole continued. Early the next morning, the cement was cored to 490.5 ft bls where basalt was encountered along with 13 carbide buttons from the air hammer bit used for reaming. At 492 ft bls, the core string was tripped out of the corehole for a new bit. While tripping the core string back into the corehole, the bit could not be placed inside the damaged 6-5/8-in. parted casing at 98 ft bls. The down-hole camera was used to guide the core string, but the bit could not be centered to enter the damaged casing. The core string and camera were tripped from the corehole and a large casing spear was tripped in the hole on the 134-core rod. This flared the top of the 6-5/8-in. casing opening. This spear was then tripped out of the corehole and the core string was tripped back into the 6-5/8-in. casing to the bottom of the corehole. Coring continue into the following day to 590 ft bls with minor problems with inner core barrel recovery and lightning. The core string was then tripped out of the corehole to recover core rubble inside the core barrel, causing it to jam while tripping back into the corehole.

The down-hole camera was used to guide the core string into the parted casing, but the top of the damaged casing had part of the collar crimped inward, which did not allow the bit to enter. The core string and camera were tripped from the corehole and a tool to open the end of the casing was tripped in the hole on the 134-core rod. When the tool was tripped out of the corehole, a 6-in. fragment of the damaged casing was recovered. The core string was then tripped back into the corehole and cored to 592 ft bls, where the inner core barrel could not be retrieved. The core string was again tripped out of the corehole to check the latching mechanism. The core barrel was cleared from cored rubble and tripped back into the corehole. It was difficult to re-enter the 6-5/8-in. casing on the trip in the hole. Coring continued to 617 ft bls until the end of the night shift the morning of May 6, 2005.

On Monday, May 9, 2005, the onsite camera was ran down the corehole to standing water at approximately 530 ft bls. This was followed with a tag line ran to 615.7 ft bls to check for the lost core down hole. An E-ling also was ran and sounded water at 535.4 ft bls. Coring continued at 617 to 632 ft bls. The core string was tripped out of the corehole to recover the missing core. The core was recovered inside the outer barrel. Lightning had temporarily shut work down followed with minor rig repair. The core string was tripped back into the corehole and coring began just after midnight the following day. Coring continued to 660 ft bls, where the inner core barrel became stuck. The core string was tripped out of the corehole and the core was recovered. The core string was tripped back down hole and coring continued all that day to 740 ft bls, where the inner core barrel would not release from the wire line overshot. Just after midnight on May 11, 2005, the core string was tripped out of the corehole and the latch mechanism was replaced. The core string was then tripped back into the corehole and coring continued for the next 2 days with minor problems to a depth of 1,030 ft bls. After tripping the core string out of the corehole to recover the core from the outer core barrel, the core string was tripped back into the corehole just above the 6-5/8-in. casing and work stopped early the following morning for the weekend.

On May 16, 2005, the core string was ran back down the corehole and coring continued until the next morning to 1,129 ft bls. The inner core barrel became stuck and the core string was tripped out of the hole. A new bit was the core put on the core barrel and the core string was ran back down the hole and coring continued to 1,136 ft bls. That afternoon, Travis McLing and Katie Helm-Clark (Bechtel's geologist and technical leads) examined the core. Coring was to end at the base of the SRPA. This is an impermeable zone in the basalt that shows hydrothermally altered mineralization with infilling of fractures and pore spaces with calcite and altered clays. Coring became very slow in dense basalt and fractures filled with calcite and clays. Coring continued until the next morning (May 18, 2005) to 1,179 ft bls. At that depth, it was determined that the base of the aquifer was reached and coring stopped. That day, the USGS ran geophysical logs inside the core string, including a gyro deviation log, and the core string was partially tripped out of the hole. The following day, a radiological control technician surveyed the recovered core in the core boxes and the driller began to move equipment off the location.

The next Monday, May 23, 2005, the USGS ran a camera down hole through the 134 rods and videoed the corehole from 433 to 679 ft bls. At that depth, the camera hit a bridge and was removed from the corehole. Open-hole logs also were run to 679 ft bls. The core rods were then tripped back down the corehole to knock out the bridge. The core was taken to the USGS core lab and photographed. On May 26, 2005, the rest of the core string was removed from the hole and the USGS video logged the corehole and ran an open-hole geophysical log to the bottom of the corehole. The core rig (UDR-1500) and remaining equipment were then moved to the next corehole location (MIDDLE-2050). The meter at the Fire Station well read 261,000 gal at the final completion of this corehole. The total amount of water used down hole while coring was 260,700 gal.

I. Summary of Well Construction Procedures:

On July 20, 2005, the driller began work on attaching 6-5/8-in. casing from the surface to the parted casing at 98 ft bls. The next day, casing was connected using a telescoped overshot of 7- and 8-in. casing (about 4 ft in length) at the end of the 6-5/8-in. casing. Bentonite was used to seal the corehole annulus and the upper outer casing.

On July 25, 2005, the bentonite was poured between the casings and between the annulus to the surface, and the core rig was put back onto the corehole for well development and water sampling. The corehole was purged and developed from July 26 to August 2, 2005, using a down-hole pump/motor and packers. Water samples were taken at each interval developed. See the field Sample Logbook ER-007-2005 (pp. 1–29) for more details. Information pertaining to pump specifications, intervals of well development, water clarity, and volumes pumped for both wells can be found in Appendix B under "Well Development."

The USGS video logged the open section of the corehole on August 18, 2005, to a depth of 1,175.5 ft bls. The temperature, natural gamma, conductivity/resistivity, and flow meter also were ran in the corehole that day. The core rig and equipment were moved to the other core site and the surface around the wellhead was leveled. The following week, on August 30, 2005, the Foremost DR-24 drill rig was moved on location along with Westbay's packer equipment. The 134 rods were tripped into the corehole and the Westbay MP55 System™ was begun to be assembled under the guidance and training of their technical engineers. See Westbay's installation report for further details. On September 12, 2005, the Westbay MP55 System™ was completed and Westbay's technician trained Bechtel's sampling team. Surface completion on the wellhead was finished on October 3, 2005.

J. Problems Encountered and Lessons Learned:

Initially, the 16-in. temporary DR casing became rock locked below the loose surface sediments in the basalt. This could not be removed and was cemented in with the 12-3/4-in. surface casing. The problems encountered during coring began with the design of the oversized CHD-134 core bit. The diamond-impregnated cutting surface had been built up from a standard OD of 5.45 in. to an OD of 5.98 in. (for the MP55 System™ installation). After wearing out six core bits from 92 to 490 ft bls, the surface cutting face was modified to allow water to flow inward to the core and a stronger, thicker cutting surface was used on the remaining bits.

Other coring problems resulted in the sticking and plugging of the inner core barrel and not being able to recover the inner core barrel with the wire line overshot tool. This resulted in numerous core string trips out of the corehole. The cause of this was from loose silts and sands from interbeds and from numerous fractured rubble zones in the basalt. The worst section seemed to be in the upper 420 ft of the corehole. The inner stainless-steel split sleeves, used to remove the core from the inner barrel with fewer disturbances, were removed to help keep the core from being lodged inside the barrel. To stop the constant sloughing of above interbed and rubble material down the corehole causing the inner barrel to become stuck, the corehole was reamed to 10-3/4 in. using an air hammer and button bit to 430 ft bls. A 6-5/8-in. casing was then installed for corehole stability.

To help advance the 6-5/8-in. casing, a 5-7/8-in. tricone bit on NQ rods was used to clean out the bottom of the reamed-out corehole. Because of down-hole conditions and the size of the drill rods used, the drill string twisted off. This was eventually recovered by using a number of fishing tools and washing and reaming over the stuck drill rods to the tricone bit. The corehole could have easily been lost at that point; however, because of the experienced drillers and drilling crew supervisor, along with communication of the project's technical leads, the methods of removing the lost drill string were agreed upon and used. Another very important tool that was used for this and all other down-hole problems was the onsite down-hole camera. It proved to be an essential tool in the understanding and correcting of problems encountered down hole in a quick and precise manner.

K. Instruments Installed in the Borehole:

See Westbay's (Schlumberger) Completion Report found in Appendix C.

4.3.3 Drawings

A. Location Maps:

See Figure 2.

B. As-Built Drawings:

See Appendix C.

5. REFERENCES

29 CFR 1910, 2005, "Occupational Safety and Health Standards," *Code of Federal Regulations*, Office of the Federal Register, November 2005.

29 CFR 1926.65, 2006, "Hazardous Waste Operations and Emergency Response," *Code of Federal Regulations*, Office of the Federal Register, January 2006.

Anderson, S. R., M. A. Kuntz, and L. C. Davis, 1999, *Geologic Controls of Hydraulic Conductivity in the Snake River Plain Aquifer at and near the Idaho National Engineering and Environmental Laboratory, Idaho*, U.S. Geological Survey Water Resources Investigations Report 99-4033 (DOE/ID-22155), p. 38.

DOE-ID, 1991, *Federal Facility Agreement and Consent Order for the Idaho National Engineering Laboratory,* Administrative Docket No. 1088-06-29-120, U.S. Department of Energy Idaho Operations Office; U.S. Environmental Protection Agency, Region 10; Idaho Department of Health and Welfare, December 4, 1991.

DOE-ID, 2002, *Waste Area Group 10, Operable Unit 10-08, Remedial Investigation/Feasibility Study Work Plan (FINAL)*, DOE/ID-10902, Rev. 0, U.S. Department of Energy Idaho Operation Office, August 2002.

DOE-ID, 2004, *Idaho National Engineering and Environmental Laboratory Operable Unit 10-08 Sitewide Groundwater Model Work Plan*, DOE/NE-ID-11188, Rev. 0, U.S. Department of Energy Idaho Operations Office, December 2004.

ER-007-2005, 2005, "WAG 10 Corehole Project (MIDDLE-2051, MIDDLE-2050A)," Environmental Operations Sample Logbook, pp. 1–29, July 13, 2005, to August 2, 2005.

ER-010-2005, 2005, "WAG 10 Corehole Project (MIDDLE-2051)," Environmental Restoration Department Record of Corehole Logbook, pp. 12–70, May 12, 2005, to October 3, 2005.

ER-011-2005, 2005, "WAG 10 Corehole Project (MIDDLE-2051)," Environmental Restoration Department Record of Corehole Logbook, pp. 12–154, 187, January 18, 2005, to May 12, 2005.

ER-056-2005, 2005, "WAG 10 Corehole Project (MIDDLE-2050, MIDDLE-2050A)," Environmental Restoration Department Record of Corehole Logbook, pp. 12–56, 76–84, May 24, 2005, to June 27, 2005.

ER-076-2005, 2005, "WAG 10 Corehole Project (MIDDLE-2050, MIDDLE-2050A)," Environmental Restoration Department Record of Corehole Logbook, pp. 12–90, 163–169, 189, June 28, 2005.

Gurney, L. G., 2004, *Health and Safety Plan for the Long-Term Stewardship Sitewide Groundwater Monitoring*, INEEL/EXT-01-01644, Rev. 4, Idaho National Engineering and Environmental Laboratory, October 2004.

ICP, 2005, *Field Sampling Plan for the Waste Area Group 10 Deep Coreholes MIDDLE-2050 and MIDDLE-2051*, ICP/EXT-05-00743, Rev. 0, Idaho National Laboratory, Idaho Cleanup Project, February 2005.

INEEL, 2005, *Drilling, Coring, and Installation of Wells Middle-2050 and Middle-2051 at the INEEL*, Blanker Master Contract No. 18825, Release No. 15, Project No. 23364, Specification No. 631, Rev. 0, Idaho National Engineering and Environmental Laboratory, January 18, 2005.

Irving, J. S., 1993, *Environmental Resource Document for the Idaho National Engineering Laboratory*, EGG-WMO-10279, Rev. 0, Idaho National Engineering and Environmental Laboratory.

Robby, M. S., 2004, *Central Facilities Area Landfills I, II, and III Annual Monitoring Report (2003)*, ICP/EXT-04-00149, Rev. 0, Idaho National Engineering and Environmental Laboratory, pp. 1–137, October 2004.

SPC-631, 2005, "Drilling, Coring, and Installation of Wells MIDDLE-2050 and MIDDLE-2051 at the INL," Rev. 1, Idaho National Laboratory, February 2005.

Appendix A

MIDDLE-2050, MIDDLE-2050A, and MIDDLE-2051 Lithology

MIDDLE-2050

Surface to 54 ft bls, with 16.5-in. dual rotary (DR) casing shoe, on 16-in. casing and 15-in. mill tooth bit; 54 to 75 ft bls with 15-in. button bit air hammer, 75 to 385 ft bls with oversized PQ core bit 5-7/8-in. diameter (3.25-in. core diameter) and 6-in. stabilizer/reamer.

Depth (ft)	Description
0–3	Surface soil (loess), silty clayey sand (SM-SC), (loess), light yellowish brown (10YR 6/4), loose grain, soft, dry to slightly moist
3–50	Silty-sandy gravel (GM), brownish gray (10YR 6/2), pebble-small cobble, very fine-coarse grain sand, subrounded, dry
50–54	Silty sandy gravel (GM), brownish-gray (10YR 6/2), pebble-small cobble, silty sand (SM), dark yellowish brown (10YR 4/4), fine-coarse grains, loose, subrounded quartz and lithic grains, moist
54–75	Basalt, vesicular, aphanitic, olivine phenocrysts medium light gray (N6), dry
75–90	Basalt, vesicular, aphanitic, strong, medium dark to dark gray (N4-N5)
90–100	Basalt, massive, dense, aphanitic, medium to dark gray (N4-N5), occasional large vesicles with few vertical small vesicle streams
100–109	Basalt, vesicular with large vesicles, aphanitic, brownish black (5YR 2/1), fractured in part with pale yellow (2.5Y 8/4) clay filling, vesicles oxidized reddish brown (5YR 3/3) with few vertical small vesicle streams
109–117.3	Basalt, massive, dense, aphanitic, dusky brown (5YR 2/2), occasional large vesicles with few vertical small vesicle streams
117.3–118	Basalt, vesicular, aphanitic, dusky brown (5YR 2/2), fractured with pale yellow (2.5Y 8/4) clay filling, fracture and vesicles oxidized reddish brown (5YR 3/3)
118–122.5	Interbed, silty clayey sand (SC-SM), soft, reddish brown (5YR 4/4) to brownish yellow (10 YR 6/6)
122.5–127.5	Basalt, vesicular, aphanitic, medium dark gray (N4) to dark gray (N5), fractured with pale yellow (2.5Y 8/4) clay filling, lower vesicles becoming large
127.5–130.2	Basalt, massive with occasional large vesicles, aphanitic, medium dark gray (N4) to dark gray (N5), fractured with pale yellow (2.5Y 8/4) clay filling, lower vesicles becoming large
130.2–145	Basalt, vesicular, rubble in part, aphanitic, medium dark gray (N4) to dark gray (N5), fractured with pale yellow (2.5Y 8/4) to reddish brown (5YR 4/4) clay filling, vesicle and fracture surfaces oxidized
145–160.8	Basalt, massive, dense, with vertical vesicles streams in part, aphanitic, medium dark gray (N3), fractured with pale yellow (2.5Y 8/4) clay filling, vesicular at base
160.8–167	Interbed, silty clayey sand (SC-SM), moderate plasticity, soft, reddish brown (5YR 5/4), base becomes calcareous (caliche) with small fragments of basalt and pinkish white (7.5YR 8/2) silts and sand, hard

(continued).

Depth (ft)	Description
167–176	Basalt, vesicular, aphanitic, medium gray (N3) to dark gray (N4), fractured with very pale brown (10YR 7/4) clay filling
176–196	Basalt, minutely vesicular with larger vertical vesicle streams in part, aphanitic, strong to medium strong, medium gray (N3), fractured with very pale brown (10YR 7/4) clay filling, infilling with basalt sand in part
196–210	Basalt, slightly vesicular with horizontal vesicle streams in part, aphanitic, gray (N4) to dusky red (5R 3/2) slightly weathered to grayish red (5R 4/2), fractured with moderate yellowish brown (10YR 5/4) clay filling, infilling with basalt sand in part
210–215	Basalt, vesicular, aphanitic, gray (N4) to grayish red (5R 4/2), fractured with moderate yellowish brown (10YR 5/4) clay filling, infilling
215–224	Inferred interbed (bedded silty clayey sand (SC-SM)), no recovery, based on drill rate and torque parameters
224–233	Basalt, vesicular to slightly vesicular, aphanitic, medium strong, medium dark gray (N4) to brownish gray (5YR 4/1), fractures and occasional vesicles have moderate yellowish brown (10YR 5/4) clay infilling
233–251.8	Basalt, minutely vesicular, aphanitic to very fine crystalline (diktytaxitic), fresh, medium dark gray (N4), fractures have very light silt to fine sand (SM) infilling, occasional horizontal vesicle streams
251.8–287.5	Basalt, massive, dense with few large vesicles, aphanitic to very fine crystalline (diktytaxitic), fresh, medium dark gray (N4), fractures have very pale brown (10YR 8/3) clay infilling, occasional horizontal vesicle streams
287.5–290	Basalt, vesicular with few large vesicles, aphanitic, medium dark gray (N4), oxidized grayish brown (5YR 3/7) to red (10R 4/6), fractures and a few vesicles have very pale brown (10YR 8/3) clay and calcite infilling, occasional horizontal vesicle streams
290–296.5	Basalt, vesicular with few large vesicles, aphanitic, dark reddish gray (10R 3/1), oxidized grayish brown (5YR 3/7) to red (10R 4/6), vesicles filled with dark red (10R 4/6) silty clayey sand (SM-SC), very calcareous, hard
296.5–297	Interbed, silty clayey sand (SM-SC), hard, dark red (10R 4/6), calcareous
297–306	Basalt, massive, dense, occasional vesicles and horizontal vesicle streams, grayish brown (5YR 3/2), very pale brown (10YR 8/3) to white (10YR 8/1) clay and calcite filling in part
306–317.5	Basalt, massive, dense, aphanitic—very fine crystalline (diktytaxitic), dark grey (N3), occasional vesicles, fractured in part with very pale brown (10YR 8/3) clay filling
317.5—~329	Basalt, vesicular to minutely vesicular, aphanitic, dark grey (N3), fractured in part with moderate yellowish brown (10YR 5/4) clay filling
~329—~331.1	Core loss, possible interbed, or most likely basalt rubble
~331.1–347.5	Basalt, vesicular to slightly vesicular, weathered to fresh, aphanitic, medium strong to strong, grayish red (10R 4/2) to medium gray (N4), fractured in part with moderate yellowish brown (10YR 5/4) clay filling

(continued).

Depth (ft)	Description
347.5–362	Basalt, vesicular to slightly vesicular, weathered to fresh, aphanitic, medium strong, brownish gray (5YR 4/1), highly fractured (rubble) with moderate yellowish brown (10YR 5/4) clay filling
362–366.9	No recovery, inferred fractured basalt
366.9–377	Basalt, minutely vesicular, aphanitic, medium gray (N4), fractured in part with yellowish brown (10YR 5/4) clay filling
377–385	Basalt, minutely vesicular to vesicular, aphanitic—very fine crystalline (zones of 1–2-mm-long plagioclase crystals-diktytaxitic), medium strong, medium gray (N4) to brownish gray (5YR 4/1), fractured in part with moderate yellowish brown (10YR 5/4) clay filling with some silt and trace of fine grain sand
385	Total Depth Cored—plugged and abandoned because of stuck core barrel and drill rods

MIDDLE-2050A

Surface to 54 ft bls, with 16.5-in. dual rotary (DR) casing shoe, on 16-in. casing and 15-in. mill tooth bit; 54 to 71 ft bls with 15-in. button bit air hammer, 71 to 420 ft bls with 15-in. button bit air hammer; 420 to 1,251 ft bls with oversized PQ core bit 5-7/8-in. diameter (3.25-in. core diameter) and 6-in. stabilizer/reamer; 1,251 to 1,333 ft bls with standard PQ core bit 5.45-in. diameter (3.25-in. core diameter) and 6-in. stabilizer/reamer; 1,333 to 1,417 ft bls with 5-7/8-in. mill tooth bit (reamed 1,251 to 1,333 ft bls); 1,417 to 1,427.4 ft bls with standard PQ core bit 5.45-in. diameter (3.25-in. core diameter) and 5.5-in. stabilizer/reamer.

Depth (ft)	Description
0–3	Surface soil (loess), silty clayey sand (SM-SC), (loess), light yellowish brown (10YR 6/4), loose grain, soft, dry to slightly moist
3–48	Silty sandy gravel (GM), brownish gray (10YR 6/2), pebble—small cobble, very fine-coarse grain sand, subrounded, dry
48–54	Silty sand (SM-SW), light brown (7.5YR 5/4), fine-medium grains, loose, subrounded quartz and lithic grains, moist
54–83	Basalt, vesicular, aphanitic, medium gray (N4), dry
83–97	Basalt, vesicular, aphanitic, dense, medium gray to dark gray (N4-N3), dry
97–119	Basalt, vesicular, aphanitic, brownish black (5YR 2/1), fractured with clay filling, moist (probably injected water from the abandoned corehole MIDDLE-2050, 15 ft to the southwest)
119–120	Interbed, silty sand (SM), soft, reddish brown, moist
120–160	Basalt, vesicular, aphanitic, dense, medium gray to dark gray (N4-N3), fractured, moist to wet, began drilling with water because of the moisture
160–166.5	Interbed, silty clayey sand (SM-SC), reddish brown
166.5–197	Basalt, slightly vesicular, dark gray (N3-N4), fractured
197–205	Basalt, slightly vesicular, dark gray (N3-N4), very fractured (fast drill rate)
205–213	Basalt, vesicular to slightly vesicular, aphanitic, blackish red (5R 2/2) to dark gray (N3)
213–215	Basalt, vesicular, aphanitic, blackish red (5R 2/2), highly fractured to rubble
215–226	Interbed, silty clay to clayey silt (SM-SC), soft, low to medium plasticity, brown (2.5YR 4/4), coarsening downward to sandy silt (SM), brown (10YR 4/3) to increase clay (SC)
226–244	Basalt, vesicular to slightly vesicular, aphanitic, dark gay (N3), fractured with minor yellowish brown (10YR 5/4) clay filling
244–288	Basalt, massive, dense, aphanitic, dark gray (N3)
288–296	Basalt, vesicular, dense, aphanitic, dark gray (N3)
296–297	Interbed, clayey silt (SC), very dusky red (10R 2/2)
297–300	Basalt, vesicular, aphanitic, dark gray (N3) to blackish red (5R 2/2)

(continued).

Depth (ft)	Description
300–320	Basalt, slightly vesicular to massive, aphanitic, dark gray (N3) to grayish brown (5YR 3/2)
320–326	Basalt, slightly vesicular to massive, aphanitic, dark gray (N3), fractured
326–334	Basalt, vesicular, aphanitic, dark gray (N3) to grayish red (10R 4/2) fractured
334–350	Basalt, slightly vesicular, aphanitic, dark gray (N3) to grayish red (10R 4/2), fractured
350–370	No returns, drilling infers fractured to rubble basalt
370–388	No returns, drilling infers hard basalt
388–397	Basalt (very few cuttings), massive, dense, aphanitic, medium gray (N5) to dark gray (N4)
397–400	Basalt (very few cuttings), massive, dense, aphanitic, medium gray (N5) to dark gray (N4), fractured
400–414	Basalt (very few cuttings), massive, dense, aphanitic, to dark gray (N4) to grayish black (N2), fractured with very pale yellow brown (10YR 8/4) clay filling, calcareous
414–418	No returns, few basalt cuttings and reddish brown foamy water—possible clayey silty (SC) interbed
418–420	Basalt, vesicular, aphanitic, grayish black (N2) to dark gray (N3), oxidized red (2.5YR 4/6) in part along the surface of vesicles, fractured with very pale yellow brown (10YR 8/4) clay filling, calcareous
420–450	Basalt, vesicular to slightly vesicular, aphanitic, medium dark gray (N4), fractured with moderate yellow brown (10YR 5/4) clay filling
450–473	Basalt, minutely vesicular, aphanitic, diktytaxitic in zones, strong, to very strong, medium dark gray (N4), fractured with moderate yellow brown (10YR 5/4) clay filling
473–475	Basalt, slightly vesicular, aphanitic, strong, to very strong, medium dark gray (N4), fractured with moderate yellow brown (10YR 5/4) clay filling, inferred top of flow break
475–482	Basalt, vesicular, aphanitic, medium strong, slightly weathered to fresh, brownish gray (5YR 4/1), fractured with moderate yellow brown (10YR 5/4) clay filling
482–502	Basalt, slightly vesicular, aphanitic, medium strong, fresh, medium gray (N4), fractured in part with moderate yellow brown (10YR 5/4) clay filling
502–504	Basalt, slightly vesicular, aphanitic, medium gray (N4) to brownish gray (5YR 4/1)
504–514	Basalt, vesicular to slightly vesicular, aphanitic, fresh to slightly weathered, possible flow break, medium gray (N4) to brownish gray (5YR 4/1)
514–517.5	Basalt, vesicular to slightly vesicular, few large vesicles—streams, aphanitic, grayish red (5R 4/2), fractures filled with very pale brown (10YR 8/4) to light yellowish brown (10YR 6/4) clay and very fine grain sand

(continued).

Depth (ft)	Description
517.5–534	Basalt, massive, dense, few vesicle streams and large vesicles, aphanitic, grayish red (5R 4/2), fractured with light yellowish brown (10 YR 8/4) clay filling
534–542.7	Basalt, massive, dense, occasional large vesicles, aphanitic, dark gray (N3) to brownish black (5YR 2/1), fractured with light yellowish brown (10 YR 8/4) clay filling, calcareous in part
542.7–544	Basalt, massive, dense, occasional vesicle zones, aphanitic, dark gray (N3) to brownish black (5YR 2/1), fractured with light yellowish brown (10 YR 8/4) clay filling, calcareous in part, dark reddish brown (5YR 3/3) oxidized fracture surfaces
544–544.5	Basalt, vesicular, oxidized dark reddish brown (5YR 3/3), fractures filled with light yellowish brown (10YR 8/4) clay
544.5–549	Interbed, silty sandy clay (SM-SC), medium stiff to stiff, moderate plasticity clay, yellowish brown (10YR 8/4) to dark reddish brown (5YR 3/4)
549–556	Basalt, vesicular to 554, aphanitic—very fine crystalline, diktytaxitic, dark gray (N3), fractured in part with calcite filling and oxidized red 2.5R 4/8) surface
556–580	Basalt, vesicular to massive, aphanitic—very fine crystalline, diktytaxitic, dark gray (N3), fractured in part with pale yellow (2.5Y 8/2) clay and calcite filling with oxidized red 2.5R 4/8) surface
580–590	Basalt, vesicular to massive, aphanitic, diktytaxitic in massive basalt, brownish black (5YR 2/1), fractured with pale yellow (2.5Y 8/2) clay and oxidized red 2.5YR 4/8) along the surface
590–600	Basalt, vesicular with large and small vesicles, dark gray (N3), fractured filled with calcareous pale yellow (2.5Y 8/2) clay
600–602.5	Basalt, highly vesicular, brownish black (5YR 2/1), fractured to rubble zone, fractures and vesicles filled with calcareous pale yellow (2.5Y 8/2) clay
602.5–606	Basalt, slightly vesicular with occasional large vesicles, aphanitic—very fine crystalline, diktytaxitic, dark gray (N3), oxidized brownish black (5YR 2/1), fractures and vesicles filled with calcareous pale yellow (2.5Y 8/2) clay
606–610.5	Basalt, massive with occasional large vesicles, aphanitic—very fine crystalline, diktytaxitic, dark gray (N3), oxidized brownish black (5YR 2/1), fractured in part, fractures and vesicles filled with calcareous pale yellow (2.5Y 8/2) clay
610.5–621	Basalt, massive with few large vesicles, aphanitic—very fine crystalline, diktytaxitic, dark gray (N3), oxidized brownish black (5YR 2/1), fractured, fractures and vesicles filled with red (10R 4/8) calcareous clay
621–626	Basalt, massive, dense, with vesicular zones, aphanitic—very fine crystalline, dark gray (N3), oxidized brownish black (5YR 8/6), fractures filled with calcareous yellow (10R 4/8) clay
626–650	Basalt, massive, dense, with vesicular zones, aphanitic—very fine crystalline, diktytaxitic, dark gray (N3), oxidized brownish black (5YR 8/6), fractures filled with calcareous yellow (10R 4/8) clay

(continued).

Depth (ft)	Description
650–657	Basalt, minutely vesicular, fresh, with diktytaxitic zones, aphanitic—very fine crystalline, strong, medium gray (N4) to dark gray (N3), oxidized brownish black (5YR 8/6), fractures filled with calcareous yellow (10R 4/8) clay
657–664	Basalt, vesicular, medium strong, aphanitic—very fine crystalline, diktytaxitic, slightly weathered, dark gray (N3), oxidized brownish black (5YR 8/6), fractures filled with calcareous yellow (10R 4/8) clay
664–675	Basalt, slightly vesicular with few large vesicles and voids, medium strong, aphanitic—very fine crystalline, diktytaxitic, dark gray (N3), oxidized brownish black (5YR 8/6), calcite infill of vesicles
675–688	Basalt, minutely vesicular, aphanitic, dark gray (N4)
688–700	Basalt, inferred flow top, vesicular, aphanitic, medium strong, fresh to slightly weathered, grayish red (5R 4/2), fractured
700–724	Basalt, slightly vesicular grading downward to minutely vesicular, aphanitic, diktytaxitic in zones, medium dark gray (N4), fractured in part
724–741	Basalt, massive, dense, aphanitic—very fine crystalline, olivine rich (weathered), medium dark gray (N4), fractured high angle with some calcite
741–741.7	Basalt, vesicular, aphanitic—very fine crystalline, olivine rich (weathered), medium dark gray (N4), oxidized dark red (10R 3/6) along fractures
741.7–742.4	Interbed, silty clayey sand (SM-SC), calcareous to moderately cemented—hard, dark red (10R 3/6) to red (10R 4/8)
742.4–745	Interbed, silty clay (SC), soft, yellowish red (5YR 4/6)
745–752.5	Interbed, silty clayey sand (SM-SC), calcareous, soft to moderately hard, yellowish red (5YR 4/6), very calcareous to caliche at basalt contact
752.5–756.7	Basalt, vesicular, aphanitic, medium dark gray (N4) to dark gray (N3)
756.7–762.5	Basalt, massive, few large vesicles, with white calcite lining, some forming small crystals, dense, fresh, aphanitic, medium dark gray (N4) to dark gray (N3)
762.5–768	Basalt, vesicular, aphanitic, medium dark gray (N4) to dark gray (N3), fractured with reddish yellow (5YR 7/8), calcareous silt filling, rubble zone in part, oxidized reddish brown (2.5Y 4/4) along fractures, white calcite filling vugs in part
768–769.5	Basalt, massive, aphanitic, medium dark gray (N4) to dark gray (N3)
769.5–779.5	Basalt, vesicular, aphanitic, medium dark gray (N4) to dark gray (N3), fractured with very pale yellow (10YR 8/2) calcareous clay filling, rubble zone in part
779.5–794	Basalt, slightly vesicular, aphanitic—very fine crystalline, diktytaxitic in part, medium dark gray (N4), fractured in part with very pale yellow (10YR 8/2) calcareous clay filling
794–806	Basalt, vesicular to massive-dense, aphanitic—very fine crystalline, diktytaxitic in part, medium dark gray (N4), fractured in part to rubble with reddish yellow (7.5YR 6/6) calcareous clay filling, fracture surfaces oxidized reddish brown (2.5YR 4/4), few large vesicles and fractures filled with white calcite

(continued).

Depth (ft)	Description
806–811.5	Basalt, massive, dense, aphanitic—very fine crystalline, diktytaxitic in part, medium dark gray (N4), with fractures and a few large vesicles filled with white calcite
811.5–831	Basalt, vesicular, aphanitic, medium dark gray (N4) to dark gray (N3), with fractures becoming rubble/cinder zone oxidized dark red (10R3/6) with very pale brown (10YR 8/3) calcareous clay filling, few large vesicles
831–844	Basalt, slightly vesicular to massive, dense, aphanitic, medium dark gray (N4), fractured in part with very little very pale brown (10YR 8/3) calcareous clay filling, few vesicles filled with white calcite
844–865	Basalt, vesicular to minutely vesicular, aphanitic, medium dark gray (N4) to dark gray (N3), fractured with yellowish red (5YR 5/6) calcareous clay filling, calcite filling and coating of vesicles
865–870	Basalt, vesicular to minutely vesicular, aphanitic, medium strong, medium gray (N5) fresh to slightly weathered grayish red (10R 4/2), fractured with yellowish red (5YR 5/6) calcareous clay filling, calcite filling and coating of vesicles
870–886	Basalt, slightly vesicular to minutely vesicular, fresh, aphanitic, diktytaxitic zones, medium gray (N5) to reddish brown (5YR 5/3), fractured with heavy infilling of calcite
886–900	Basalt, slightly vesicular to vesicular, aphanitic, medium gray (N5) to reddish brown (5YR 5/3), fractured with infilling of reddish brown (2.5YR 4/4) calcareous clay, vesicles contain brownish yellow (10YR 6/6) clay infill
900–906.5	Basalt, slightly vesicular, aphanitic, medium strong, medium gray (N5) fresh to slightly weathered brownish gray (5YR 4/1)
906.5–907.3	Interbed, baked silts and clay (SC), red (10R 4/6)
907.3–914	Basalt, vesicular to slightly vesicular, aphanitic, medium strong, medium gray (N4) weathered brownish gray (5YR 4/1), fractured in part with calcite infilling of both fractures and vesicles
914–919.5	Basalt, massive with vesicular zones and few large vesicles, aphanitic, diktytaxitic, very dark gray (10YR 3/1), fractured in part
919.5–924	Basalt, vesicular, aphanitic, very dark gray (10YR 3/1), oxidized dark reddish gray (2.5YR 3/1) and red (10R 4/6) along fractures, occasional white calcite filling
924–926	Basalt, massive-dense to slightly vesicular, aphanitic—very fine crystalline, diktytaxitic, medium gray (N4), occasional white calcite fracture filling
926–935.3	Basalt, vesicular, aphanitic, very dark gray (5YR 3/1), fractured with dark red (10R 3/6) oxidized staining fracture surfaces and occasional white calcite filling
935.3–937	Basalt, massive, dense, aphanitic—very fine crystalline, diktytaxitic in part, medium gray (N5), occasional white calcite fracture filling
937–942	Basalt, vesicular, aphanitic, medium gray (N5), highly fractured to rubble, oxidized dark red (10R 3/6), occasional white calcite vesicle filling

(continued).

Depth (ft)	Description
942–953	Basalt, vesicular, aphanitic with visible feldspar crystals, diktytaxitic, dark gray (N3) to brownish black (5YR 2/1), highly fractured to rubble/cinder, oxidized dark red (10R 3/6), occasional white calcite vesicle and fracture filling
953–961	Basalt, massive, dense, vesicular in part, aphanitic—very fine crystalline, diktytaxitic, medium gray (N5) oxidized brownish black (5YR 2/1), occasional white calcite vugs/vesicle filling
961–975	Basalt, massive, dense, vesicular in part, aphanitic—very fine crystalline, diktytaxitic, medium gray (N5) to medium dark gray (N4), oxidized brownish black (5YR 2/1), occasional white calcite vugs/vesicle filling
975–985	Basalt, minutely vesicular to vesicular, aphanitic, diktytaxitic in zones, fresh, strong to very strong, dark gray (N3)
985–990	Basalt, inferred flow top, vesicular, aphanitic, strong to very strong, slightly weathered, grayish red (5R 4/2), fractures contain heavy (up to 0.5 in.) infilling of calcite crystals
990–1,000	Basalt, slightly vesicular to minutely vesicular, aphanitic, fresh, diktytaxitic in zones, medium dark gray (N4)
1,000–1,015	Basalt, vesicular to minutely vesicular, aphanitic, yellow brown (10YR 4/2) to medium gray (N5), fractured with moderate to some calcite infilling
1,015–1,023.2	Basalt, massive, dense, occasional vesicles and vesicle streams, aphanitic—very fine crystalline, dark gray (N3) to brownish black (5YR 2/1), fractured with white calcite infilling
1,023.2–1,043.6	Basalt, massive, dense, occasional vesicles zones, aphanitic—very fine crystalline, diktytaxitic, very dark gray (10YR 3/1), fractured (some high angle) with white calcite infilling
1,043.6–1,051.2	Basalt, vesicular, aphanitic—very fine crystalline, medium gray (N5) oxidized brownish black (5YR 2/1), fractured with euhedral calcite crystals along fractures and in vugs
1,051.2–1,061	Interbed, silty clayey sand (SM-SC), moderate hard, red (10R 4/6) to brown (10R 4/4), calcareous zones with white calcite/caliche flakes, also near top of basalt
1,061–1,064.5	Basalt, vesicular to massive, aphanitic, medium gray (N4) to dark gray (N3), fractures and vugs/vesicles line with calcite crystals
1,064.5–1,083	Basalt, minutely vesicular to massive, aphanitic, diktytaxitic, strong, fresh, medium gray (N4), elutriation tube (vertical vesicle stream) with calcite infilling
1,083–1,099	Basalt, slightly vesicular, aphanitic, diktytaxitic, strong, fresh, medium gray (N4), fractured with yellow (10YR 8/6) clay filling, white to clear calcite fracture lining and occasional vesicle infilling
1,099–1,113.9	Basalt, massive, dense, with few large vesicles and horizontal vesicle streams, aphanitic, dark gray (N3) to grayish black (N2), fractured in part with very pale brown (10YR 8/4) clay filling
1,113.9–1,114.5	Basalt, vesicular, aphanitic, dark gray (N3) to grayish black (N2)

(continued).

Depth (ft)	Description
1,114.5–1,119	Interbed, silty clayey sand (SM-SC), very dense—hard becoming soft and sandy, red (10R 5/8), calcareous to caliche at base and yellowish red (2.5YR 3/6)
1,119–1,150	Basalt, vesicular, very fine crystalline, diktytaxitic, dark gray (N3) to brownish black (5YR 2/1), fractured with interbed filling, rubble in part, occasional calcite lined vugs/vesicles (oxidized in part)
1,150–1,189	Basalt, vesicular to massive, aphanitic, diktytaxitic in some zones, strong, medium dark gray (N4)
1,189–1,190	Basalt, vesicular to massive, aphanitic, diktytaxitic in some zones, strong, medium dark gray (N4), fractured with brown (10YR 5/3) silty clayey sand (SM-SC) infilling
1,190–1,191	Interbed, silty clayey sand (SM-SC), hard baked, oxidized red (10R 4/8) to red (2.5YR 5/8), calcareous with white caliche at base
1,191–1,199	Basalt, vesicular to massive, aphanitic, medium gray (N4) oxidized in part, vesicles and fractures filled with calcite in part
1,199–1,221	Basalt, vesicular to massive, aphanitic to very fine crystalline (diktytaxitic), medium dark gray (N4), fractured with yellowish red (5YR 5/6) calcite and silty clay (SC) filling, occasional calcite filling vesicles/vugs, oxidized fracture and vesicle surfaces
1,221–1,227	Basalt, massive with occasional large vesicles, aphanitic to very fine crystalline (diktytaxitic), medium dark gray (N4), fractured with very pale brown (10YR 7/3) calcite and silty clay (SC) filling, occasional calcite filling vesicles/vugs, oxidized fracture and vesicle surfaces
1,227–1,229.8	Basalt, vesicular with occasional large vesicle, aphanitic, medium dark gray (N4), fractured with very pale brown (10YR 7/3) calcite and silty clay (SC) filling, occasional calcite filling vesicles/vugs, oxidized dark reddish brown (2.5YR 3/3) fracture and vesicle surfaces
1,229.8–1,231	Basalt, massive, aphanitic, medium dark gray (N4), oxidized dark reddish brown (2.5YR 3/3), fractured with very pale brown (10YR 7/3) calcite and silty clayey sand (SC-SM) filling
1,231–1,251	Basalt, slightly vesicular, aphanitic, medium gray (N4), some calcite infilling of vesicles and fractures, very fine (<1/32 in.) infilling of clay on fractures
1,251–1,266.9	Basalt, massive, dense, occasional large vesicles and horizontal vesicle streams, aphanitic—very fine crystalline, medium dark gray (N4), fractured in part with pale brown (10YR 8/3) clay filling, occasional white calcite filling vesicles
1,266.9–1,277	Basalt, highly vesicular, aphanitic—very fine crystalline, dark gray (N3) oxidized dark red (10R 3/6), highly fractured to rubble/cinder, pale brown (10YR 8/3) to pale yellow (2.5Y 7/4) clay filling of fractures and vesicles
1,277–1,280	Basalt, vesicular, aphanitic—very fine crystalline, dark gray (N3) oxidized strong brown (7.5YR 5/6) near vesicles, highly fractured, pale yellow (2.5Y 8/4) clay filling of fractures and vesicles

(continued).

Depth (ft)	Description
1,280–1,282.5	Interbed, dense structureless clay with trace of silt (CL-SC), grayish brown (2.5Y 5/2)
1,282.5–1,285	No recovery, inferred interbed
1,285–1,288	Interbed, silty clay (SC), grading sharply into clayey silty sand (SC-SM), very fine lithic and quartzes grains, subrounded, calcareous, occasional biotite, very dense, pale yellow (2.5Y 7/3)
1,288–1,295	No recovery, inferred interbed
1,295–1,303	Interbed, clayey silty sand (SC) to silty sand (SM), fine grain, loose to dense, very calcareous near bottom, hard, pale yellow (2.5Y 7/3)
1,303–1,311	Interbed, silty sand (SM), thick bedded, subrounded-rounded, well sorted, poorly graded, fine grain, calcareous, pale yellow (2.5Y 7/3)
1,311–1,316.5	No recovery, inferred interbed
1,316.5–1,320	Interbed, silty clay (SC-ML), stiff, calcareous, olive brown (2.5Y 4/3), oriented layers of gray (2.5Y 6/1) chips of silty sandy clay (SM-SC), chips look like curled mud cracks
1,320–1,325	No recovery, inferred interbed
1,325–1,333	Interbed, silty clay (SC-ML), stiff-hard, calcareous, olive brown (2.5Y 4/3) to light olive brown (2.5Y 5/3), oriented layers of gray (2.5Y 6/1) to light bluish gray (GLEY2 8/10B) chips of silty sandy clay (SM-SC), chips look like curled mud cracks
1,333–1,380	Drilling with conventional mill tooth bit, no returns (Note: Gamma ray from neutron log shows bottom of interbed at 1,380 ft bls.)
1,380–1,417	Drilling with conventional mill tooth bit, no returns
1,417–1,427.4	Basalt, altered, vesicular to slightly vesicular, aphanitic, medium dark gray (N4), fractured filled with calcite, vesicles filled with altered/weathered olivine
1,427.4	Total Depth Cored

MIDDLE-2051

Surface to 127 ft bls, 15-in. button bit with air hammer; surface to 107 ft bls, 16-in. dual rotary (DR) casing with 17-in. DR casing/cutting shoe; 127 to 1,179 ft bls with oversized PQ core bit 5-7/8-in. diameter (3.25-in. core diameter) and 6-in. stabilizer/reamer.

Depth (ft)	Description
0–3	Surface soil (loess), silty clayey sand (SM), light yellowish brown, slightly moist, loose grain
3–20	Sandy gravel (GM-GW), grayish brown, small pebble, rounded, loose grain, slightly moist
20–23	Silty clayey sand grading to sandy silt (SC-SM), very fine to medium grained, subangular to subrounded, grayish brown, slightly moist
23–25	Silty sandy gravel (GM), subrounded to subangular, greater than 1 in., quartzite, limestone, andesite/dacite, sand grains fine to very coarse
25–26	Sandy silt (SM), very fine to fine grain, medium brown to gray brown
26–31	Silty sandy gravel (GM), subrounded to subangular, greater than 1 in., quartzite, basalt, and limestone
31–43	Sandy silt, (SM), very fine to fine grain, brown (7/5YR) to gray brown (10YR 4/3)
43–43.5	Silty sandy gravel (GM), subrounded to subangular, greater than 1 in., quartzite, basalt, and limestone
43.5–50.5	Sandy silt (SM), fine grained, brown (10YR 4/3) to gray brown (10YR 5/2)
50.5–56	Silty sandy gravel (GM), fine to coarse grain, subrounded to subangular, greater than 1 in., quartzite, limestone, andesite/dacite, sand grains fine to very coarse
56–63	Silty sand (SM), fine to very fine grain, dark gray (10YR 4/1) to gray brown (10YR 4/2), (Note: Fresh basalt was observed in the sample.)
63–65	Sandy gravel to silty sandy gravel (GW), medium to very coarse grain, greater than 2 in., subangular to rounded, very dark gray to very dark gray brown (10YR 3/1 to 3/2)
65–75	Silty sand (SM), fine to very fine grain, dark gray (10YR 4/1) to gray brown (10YR 4/2)
75–78	Sand (SW), very coarse to coarse grain, well sorted subangular to subrounded, basalt, limestone, chert, quartzite, dark gray brown (10YR 4/2)
78–92	Silty sand (SM), fine to coarse grain, angular to subrounded, dark gray brown (10YR 4/2)
92–100	Basalt, rubble, diktytaxitic, dark gray to dark red gray, coarse lithic sand and clayey silt (reddish gray) in returns
100–107	Returns as dust only, unable to collect discrete sample

(continued).

Depth (ft)	Description
107–120	Basalt, slightly vesicular, rubble/cinders, most returns as dust, gray (5Y 6/1), fragments of cinders are (10R 4/1), basalt is weak rock ~ 5%, olivine and plagioclase, euhedral
120–127	Basalt, vesicular to massive (small cuttings), gray (GLEY 1 5/N), very fine crystalline, occasional olivine, abundant feldspar (white) crystals
127–132	Basalt, massive, very fine crystalline, dark gray (GLEY 4/N)
132–139.5	Basalt, vesicular to massive, aphanitic to very fine crystalline, dusty red (10R 3/2) to dark reddish gray (10R 3/1), fractured, rubble zone at 137.8 to 139.5 ft
139.5–141.5	No recovery
141.5–142.8	Interbed, silty-sand (SM-SW), reddish brown (5YR 4/4), very fine to fine grain, quartz and lithic grains, subrounded, very dark gray (10YR 3/1)
142.8–149.5	Basalt, small vesicles to massive, very fine crystalline, dark gray (GLEY 3/N) to dark reddish brown (5YR 3/2)
149.5–153	No recovery, trace of interbed, silty clayey sand (SM), yellow red (5YR 4/6), moderately stiff
153–170.5	Basalt, vesicular with some large, very fine crystalline to aphanitic, fractures filled with interbed, very dark gray (10YR 3/1 to GLEY 1 3/N), oxidized dark reddish brown (5YR 3/2) along fractures and some vesicles
170.5–177	No recovery
177–194	Basalt, massive with occasional vesicle zones, aphanitic to very fine crystalline, black (GLEY1 2.5/1) to dark olive gray (5Y 3/2), fractured, with yellow red (5YR 5/67) to yellow (10YR 8/6) clay filling in part and oxidized dark reddish brown (5YR 2 5/2) along fractures and vesicles
194–207	Basalt, massive, very fine crystalline to aphanitic, black (5YR 2.5/1) to dark olive gray (5Y 3/2)
207–225.8	Basalt, massive, very fine crystalline to aphanitic, black to dark reddish brown (5YR 3/1-2.5YR 3/4), fractured in part with pale yellow (2.5Y 8/4) clay filling, fractured surfaces oxidized red-hematite (not red die from RWMC), white calcite (5YR 8/1)
225.8–226.5	Interbed, silty clayey sand (SM-SC), red (2.5YR 4/8), hard, calcite cemented
226.5–230.5	Basalt, vesicular, aphanitic, dark reddish brown (5YR 2.5/2), vesicles filled with white calcite (5YR 8/1), fractured in part
230.5–249.5	Basalt, few large vesicles becoming massive, very fine crystalline to aphanitic, black (2.5/1), occasional horizontal vesicle streams associated with pale yellow clay filling (2.5Y 8/4)
249.5–250.7	Basalt, vesicular, very fine crystalline to aphanitic, black (5YR 2.5/1), fractured filled with yellow clay (2.5Y 8/4) and white calcite (5YR 8/1)
250.7–251.7	Interbed, silty clayey sand (SM-SC), yellow red (5YR 5/8), soft, calcite cemented

(continued).

Depth (ft)	Description
251.7–260	Basalt, vesicular, aphanitic, black (GLEY1 2.5/N), fractures filled with white calcite (5YR 8/1)
260–273.5	Basalt, massive with occasional vertical vesicle streams, aphanitic to very fine crystalline, black (GLEY1 2.5/1), fractured, with pale yellow (2.5Y 8/4) clay and white calcite (5YR 8/1) filling
273.5–278.7	Basalt, vesicular, aphanitic to very fine crystalline, black (GLEY1 2.5/1), fractured, with pale yellow (2.5Y 8/4) clay and white calcite (5YR 8/1) filling, fractures oxidized dark reddish brown (5YR 3/3), rubble/cinders in part, dusky red (10R 3/4)
278.7–286	Basalt, massive to vesicular, aphanitic, dark reddish gray (10R 3/1), fractured, with pale yellow (2.5Y 8/4) clay and white calcite (5YR 8/1) filling
286–294.5	Basalt, massive, aphanitic, dark reddish gray (10R 3/1), fractured, with pale yellow (2.5Y 8/4) clay filling
294.5–305.7	Basalt, vesicular-massive, aphanitic, dark reddish gray (10R 3/1) to dusky red (10R 3/3), fractured, with brownish yellow (10YR 6/6) clay filling
305.7–306.2	Basalt, vesicular cinders, dusky red (10R 3/3), clay, brownish yellow (10YR 6/6), zone
306.2–310.5	Basalt, vesicular-massive, aphanitic, dark reddish gray (10R 3/1) to dusky red (10R 3/3), fractured, with brownish yellow (10YR 6/6) clay filling
310.5–313	Basalt, massive, aphanitic, reddish black (2.5YR 2.5/1), fractured
313–313.5	Interbed, sand (SW), reddish brown (5YR 4/1), medium grain, subrounded, quartz and lithic grains, loose
313.5–319.2	Basalt, massive to vesicular, aphanitic, reddish black (2.5YR 2.5/1), fractured, with brownish yellow (10YR 6/6) clay filling
319.2–319.4	Basalt, vesicular cinders, dark reddish brown (5YR 3/4), clay, brownish yellow (10YR 6/6), zone
319.4–329.5	Basalt, vesicular, aphanitic, black (10YR 2/1), fractured, with brownish yellow (10YR 6/6) clay filling
329.5–341	Basalt, vesicular, aphanitic, dusky red (10R 3/3), fractured, rubble in part with brownish yellow (10YR 6/6) clay filling
341–352	Basalt, lightly vesicular, aphanitic to very fine crystalline, black (GLEY1 2.5/N), fractured, with brownish yellow (10YR 6/6) clay filling
352–357	Basalt, massive, aphanitic to very fine crystalline, diktytaxitic, black (GLEY1 2.5/N), fractured with brownish yellow (10YR 6/6) clay filling
357–380.5	Basalt, vesicular to massive with occasional horizontal vesicle streams, aphanitic to very fine crystalline, black (GLEY1 2.5/N), fractured with brownish yellow (10YR 6/6) clay filling, fracture surface oxidized yellow (10YR 8/3) to dark reddish brown (2.5YR 3/4)
380.5–381.4	Basalt, vesicular, aphanitic, black (GLEY1 2.5/N), fractured with yellow (10YR 7/8) to greenish black (GLEY1 2.5/N/10Y), thick silty clay (SC) filling, soft, medium plasticity

(continued).

Depth (ft)	Description
381.4–388.5	Trace of interbed, silty sand (SM), red (2.5YR 5/6), medium grain, subrounded, loose, (~7.1 ft washed away?)
388.5–399.5	Basalt, vesicular, aphanitic, black (GLEY1 2.5/N), fractured, with yellow (10YR 7/8) clay filling, oxidized red (10R 4/6) along vesicles/fracture surfaces
399.5–406.5	Basalt, massive, diktytaxitic with olivine, dense, aphanitic, black (GLEY1 2.5/N), few large vesicles and horizontal vesicle streams, fractured, with yellow (10YR 7/8) clay filling, oxidized red (10R 4/6) along vesicles/fracture surfaces
406.5–413.7	Basalt, massive, diktytaxitic with olivine, dense, aphanitic, dusky red (10YR 3/2), few horizontal vesicle streams, fractured, with yellow (10YR 7/8) clay filling, oxidized red (10R 4/6) along vesicles/fracture surfaces
413.7–416.5	Basalt, vesicular, aphanitic, black (GLEY1 2.5/N), few horizontal vesicle streams, fractured, with yellow (10YR 7/8) clay filling, oxidized red (10R 4/6) along vesicles/fracture surfaces
416.5–424.5	Basalt, rubble zone, vesicular, aphanitic, dusky red (10YR 3/2), fractured, with dark reddish gray (2.5YR 3/1) clay filling
424.5–430.5	Basalt, massive, dense, aphanitic, black (GLEY1 2.5/N), fractured
430.5–435	Basalt, vesicular, aphanitic, black (GLEY1 2.5/N), fractured to rubble in part, with yellow (10YR 7/8) to weak red (10R 4/3), clay filling, oxidized red (10R 4/6) along fracture surfaces
435–444	Basalt, massive, dense, aphanitic, black (GLEY1 2.5/N), vesicular in part, fractured, oxidized weak red (10R 4/3) surface
444–448	Interbed, silty clayey sand-silty sand-sand (SC-SM-SW), dusky red (10R 3/3), fine to coarse grain, subrounded, SC-medium plasticity, mixed with basalt fragments, dark grayish brown (2.5Y 5/1)
448–453	Basalt, massive, dense, very fine crystalline, very dark gray (GLEY1 3 /N), diktytaxitic with olivine crystals, fractured, yellow (10YR 7/8) clay filling, large vugs /vesicle in part
453–455.4	Interbed, silty clayey sand-silty sand-sand (SC-SM-SW), dusky red (10R 3/3), fine to coarse grain, subrounded, SC-medium plasticity, mixed with basalt fragments, dark grayish brown (2.5Y 5/1)
455.4–465	Basalt, vesicular, aphanitic, very dark gray (GLEY1 3 /N), fractured with yellow (10YR 7/8) to reddish yellow (5YR 7/6) clay filling, oxidized strong brown (7.5YR 5/6) to dark reddish brown (5YR 2 5/2) along fracture surfaces
465–468	No recovery
468–471.6	Basalt, vesicular, aphanitic, black (10YR 2/1), oxidized dark reddish brown (5YR 3/4) in part, vesicles and fractured filled with yellow (10YR 7/8) clay
471.6–483.4	Basalt, massive, dense, very fine crystalline—aphanitic, black (GLEY1.2 5 /N), diktytaxitic, few large vesicles with both vertical and horizontal streams

(continued).

Depth (ft)	Description
483.4–490.5	Basalt, vesicular to massive, aphanitic—very fine crystalline, dense in part, black (10YR 2/1), yellow clay (10YR 8/6) filled fractures and vesicles, oxidized red (10R 2/1) surfaces
490.5–492.8	Basalt, vesicular, aphanitic, dark reddish gray (2.5YR 3/1), oxidized dark reddish brown (5YR 3/4) in part, very pale brown clay (10YR 7/4) filled fractures, soft, with small fragments of calcareous silty clay (SC), very pale brown (10YR 8/2) fracture filling, hard
492.8–498.4	Basalt, vesicular, aphanitic, very dark gray (GLEY1 3/N), yellow clay (10YR 8/6) filled fractures and vesicles, oxidized red (10R 2/1) surfaces, few large vesicles
498.4–502	Basalt, highly vesicular, aphanitic, black (5YR 2.5/1), oxidized dark reddish brown (5YR 3/3) vesicle surfaces
502–503	No recovery
503–515.5	Basalt, strong, slightly to minutely vesicular, fresh, aphanitic, diktytaxitic in part, medium gray (N4 to N5), fractured in part
515.5–526	Basalt, (inferred flow top/bottom), vesicular, aphanitic, slightly weathered, reddish gray to weak red (10R 4/4), fractured with very pale brown (10 YR 7/4) clay filling
526–541.6	Basalt, strong, minutely vesicular with occasional large vesicles, aphanitic, medium gray (N5)
541.6–554.8	Basalt, massive, dense, isolated highly vesicular zones with occasional large vesicles, aphanitic, gray (N5)
554.8–564	Basalt, massive, dense, aphanitic, olivine, occasional large vesicles, aphanitic, gray (N5) to black (5Y 2.5/1), fractured with yellow (10YR 7/6) clay filling
564–568.3	Basalt, very fine scattered vesicles, aphanitic—very fine crystalline, very dark gray (10R 3/1), fractured with yellow (10YR 7/6) clay filling and oxidized reddish brown (2.5YR 4/4) surface
568.3–573.5	Basalt, highly vesicular with occasional large vesicles, aphanitic, oxidized red gray (2.5YR 3/2), highly fractured flow top/bottom, yellow (10YR 7/6) clay filling and oxidized reddish brown (2.5YR 4/4) surface
573.5–603.5	Basalt, occasional large vesicles, aphanitic, very dark gray (10YR 3/1) to black (5Y 2.5/1), highly fractured with yellow (10YR 7/6) clay filling and oxidized reddish brown (2.5YR 4/4) surface
603.5–615	Basalt, fresh, slightly to minutely vesicular, aphanitic, strong, dark gray (N4-N5), fractured with yellow (10YR 7/6) clay filling
615–617	Basalt, massive to vesicular, aphanitic—very fine crystalline, dense, olivine, black (5Y 2.5/1), fractured with yellow (10YR 7/6) clay filling
617–623.5	Interbed, silty sand (SM), fine-medium quartz and lithic grains, subrounded, loose, brown (7.5 YR 5/3)
623.5–629.8	Basalt, massive with occasional small vesicles, aphanitic—very fine crystalline, dense, olivine, dark gray (GLEY1 4/N), fractured with yellow (10YR 7/6) clay filling

(continued).

Depth (ft)	Description
629.8–634.5	Interbed, silty sand (SM), fine-medium quartz and lithic grains, subrounded, loose, brown (7.5 YR 5/3)
634.5–639	Basalt, vesicular with some calcite mineralization, aphanitic, medium dark gray (N4-N5)
639–656.7	Basalt, vesicular to massive, aphanitic, strong to very strong, medium dark gray (N4-N5), occasional large vesicles and horizontal vesicle streams “lamination bands”
656.7–668	Basalt, vesicular, aphanitic, medium dark gray (N5), fractured with yellow (10YR 7/6) clay and silty clay (SC) fillings
668–673.5	Basalt, vesicular, aphanitic, black (10YR 2/1), fractured filled with very pale yellow (10YR 7/6) clay, surface oxidized dark reddish brown (5YR 3/2)
673.5–674	Interbed, silty clay (ML), very pale yellow (10YR 8/4)
674–685.5	Basalt, massive with occasional large vesicles, aphanitic, dense, dark reddish brown (5YR 3/2), fractured filled with very pale yellow (10YR 7/6) clay, fracture and vesicle surfaces oxidized dark reddish brown (5YR 3/2)
685.5–702.2	Basalt, vesicles to massive with occasional large vesicles and clear calcite crystals, aphanitic, dense, dark reddish brown (5YR 2.5/1), fractured filled with yellow (10YR 7/4) clay
702.2–704	Interbed, silty clay sand (SC-SM), moderate stiff, dark red (10YR 4/8)
704–711	Basalt, slightly weathered, vesicles with occasional minor calcite crystals, aphanitic—very fine crystalline (3–10 mm plagioclase phenocrysts), medium strong grading downward to strong, dusky red (10R 3/4), fractured filled with yellow (10YR 7/4) clay, inferred lower flow contact
711–712.9	Interbed, sandy silt with some clay (SM-SC), baked, dark yellowish brown (10YR 4/4), thin basalt layer, vesicular, slightly weathered, aphanitic, medium gray (N5), with minor calcite infilling of vesicles, then interbed as above with gravel-size basalt inclusions
712.9–740	Basalt, slightly weathered grading downward to fresh vesicles with occasional calcite crystals filling, aphanitic, dusky red (10R 3/2), fractured
740–748.5	Basalt, fresh, minutely vesicular, aphanitic with diktytaxitic zones, 2–5 mm long lath phenocrysts of plagioclase, dense, medium gray (N4-N5)
748.5–777	Basalt, vesicular to massive, aphanitic—very fine crystalline, diktytaxitic (plagioclase laths), dense, medium gray (N4-N5), fractured filled with very pale yellow (10YR 7/6) clay, fracture and vesicle surfaces oxidized dark reddish brown (5YR 3/2), rubble in part
777–782	Basalt, vesicular, with numerous small vesicles, aphanitic—very fine crystalline, diktytaxitic (plagioclase laths), black (10YR 2/1), fractured in part filled with very pale yellow (10YR 7/6) clay filling
782–803.5	Basalt, massive with large scattered vesicles and some horizontal vesicle streams, aphanitic—very fine crystalline, black (10YR 2/1), fractured in part filled with very pale yellow (10YR 7/6) clay filling

(continued).

Depth (ft)	Description
803.5–817	Basalt, massive with large scattered vesicles, aphanitic—very fine crystalline, black (10YR 2/1), vertical fractured to rubble zone with very pale yellow (10YR 7/6) clay filling
817–829.7	Basalt, minutely vesicular, aphanitic—very fine crystalline, dark gray (N4), medium strong to strong, fractured in part
829.7–839.3	Basalt, inferred flow top, vesicular, aphanitic, dark gray (N4) to dark reddish gray (10R 3/1), slightly weathered grading downward to fresh, strong, fractured in part with minor vesicle infilling and secondary mineralization
839.3–847	Basalt, slightly vesicular to vesicular, occasional calcite infilling of vesicles, aphanitic, dark gray (N4), strong, slightly weathered, fractured with very pale yellow (10YR 7/6) clay filling
847–861.2	Basalt, massive, dense, aphanitic, reddish black (10R 2.5/1), occasional medium-large vesicles, fractured with small amount of calcite and greenish gray (GLEY1 8/1) clay infilling
861.2–869	Basalt, vesicular, aphanitic, reddish black (10R 2.5/1), occasional medium-large vesicles, fractured with small amount of calcite and greenish gray (GLEY1 8/1) clay infilling
869–881	Basalt, massive, dense, aphanitic—very fine crystalline (plagioclase laths), reddish black (10R 2.5/1), occasional small to large vesicles, fractured with small amount of white calcite infilling
881–889	Basalt, vesicular, aphanitic, reddish black (10R 2.5/1) to black (5YR 2.5/1), occasional large vesicles, highly oxidized red (10R 4/8) fracture surface with yellow (10YR 8/3) clay and calcite filling
889–901.7	Basalt, vesicular to massive, highly vesicular in part, aphanitic-very fine crystalline, black (5YR 2.5/1), occasional large vesicles, oxidized red (10R 4/8) fracture surface with yellow (10YR 8/3) clay and white to clear euhedral calcite filling
901.7–905.5	Basalt, vesicular, aphanitic, dark reddish brown (2.5YR 3/4), occasional large vesicles, oxidized red (10R 4/8) fracture surface with yellow (10YR 8/3) soft clay and white to clear euhedral calcite fracture filling, rubble in part
905.5–911	Basalt, inferred top of flow break, vesicular to highly vesicular, aphanitic, very dusky red (2.5/ 1), occasional white to clear euhedral calcite fracture and large vesicle filling, rubble in part
911–919.6	Basalt, massive, dense, aphanitic—very fine crystalline (diktytaxitic), very dark gray (GLEY1 3/N), fractured in part with white calcite and yellow (2.5Y 7/3) clay filling
919.6–929.4	Basalt, vesicular, rubble in part, aphanitic, oxidized dark reddish gray (10R 3/1) to red (10R 4/6), fractured with pale yellow (2.5Y 7/3) clay and white calcite filling
929.4–950.3	Basalt, massive with few small vesicles, very fine crystalline diktytaxitic (lath shape phenocrysts of plagioclase), medium gray (N4) to dusky red 10R 3/2), medium strong to strong, fractured with yellowish brown (10YR 5/4) clay and vesicle filling

(continued).

Depth (ft)	Description
950.3–985	Basalt, massive with few large vesicles and streamers of horizontal vesicles, very fine crystalline, diktytaxitic, medium gray (N4) to dusky red 10R 3/2), fractured with pale yellow (2.5Y 8/1) clay filling
985–1,005	Basalt, massive with few large vesicles and streamers of horizontal vesicles, very fine crystalline, diktytaxitic with plagioclase laths and olivine phenocrysts, medium gray (N4) oxidized dusky red 10R 3/2) in part, fractured with pale yellow (2.5Y 8/1) clay and white calcite filling
1,005–1,006.1	Basalt, vesicular with few large vesicles and streamers of horizontal vesicles, medium gray (N4) oxidized dusky red 10R 3/2) in part, fractured with light yellowish brown (2.5Y 6/3) to strong brown (7.5 YR 5/6) clay and white calcite filling
1,006.1–1,010.4	Interbed, silty clay-silty sand (SC-/SM) and clay (CL), dusky red (10R 3/4) to brown (7.5YR 4/4), minor calcite accretions with grayish green (GLEY1 6/1) clay, occasional weathered vesicular basalt fragments
1,010.4–1,024.5	Basalt, vesicular, aphanitic with plagioclase laths, weathered reddish black (10R 2.5/1), calcite accretions in vesicles, fractures containing white calcite (caliche)
1,024.5–1,028	Basalt, massive, aphanitic with plagioclase laths (diktytaxitic), weathered reddish black (10R 2.5/1), calcite accretions in vesicles, fractures containing white calcite (caliche) to euhedral clear calcite, and dusky red (10R 3/4) to brown (7.5YR 4/4) clay filling
1,028–1,061	Basalt, vesicular, aphanitic with plagioclase laths 2–5 mm, dusky red (10R 3/2), occasional fractures filled with calcite
1,061–1,064	Basalt, massive, dense, few horizontal vesicle streams aphanitic with plagioclase laths 2–5 mm, dusky red (10R 3/2)
1,064–1,077.6	Basalt, vesicular to highly vesicular, aphanitic, reddish black (10R 2.5/1), inferred flow top, fracture and vesicle surfaces oxidized dark red (10R 3/6) to dusky red (10R 3/3), white to clear calcite filling scattered with some reddish yellow (5YR 7/6) clay filling
1,077.6–1,079	Basalt, massive with occasional vesicles, dense, aphanitic—very fine crystalline, reddish black (10R 2.5/1), fracture and vesicle oxidized dusky red (10R 3/3), with occasional white to clear calcite filling
1,079–1,088	Basalt, highly vesicular, aphanitic, black (7.5YR 2.5/1) oxidized reddish black (10R 2.5/1) along vesicle and fracture surfaces, soft rubble
1,088–1,095	Basalt, massive, dense, vesicular in part, aphanitic, black (7.5YR 2.5/1) oxidized reddish black (10R 2.5/1) along vesicle and fracture surfaces and healed with calcite
1,095–1,100	Basalt, highly vesicular, inferred flow top, aphanitic, black (7.5YR 2.5/1) oxidized dark red (10R 3/6) along vesicle and fracture surfaces, fractures healed with calcite
1,100–1,115	Basalt, vesicular, aphanitic, black (7.5YR 2.5/1) oxidized dark red (10R 3/6) along vesicle and fracture surfaces, fractures healed with calcite, vesicles filled with calcite and clay in part

(continued).

Depth (ft)	Description
1,115–1,124	Basalt, vesicular, aphanitic, heavily oxidized dusky red (10R 3/2), (vent proximal?), vesicles elongated and heavy to completely filled with greenish calcite
1,124–1,127.8	Basalt, vesicular, aphanitic, black (5YR 2.5/1) to dark reddish brown (5YR 3/2), fractured in part, calcite filling in few of the vesicles and fractures
1,127.8–1,138	Basalt, massive, dense, aphanitic—very fine crystalline (diktytaxitic), scattered horizontal vesicle zones with few large vesicles near the bottom of core, black (5YR 2.5/1) to dark reddish brown (5YR 3/2), fractured in part, calcite filling in a few of the vesicles and fractures, altered secondary crystallization in large vesicles
1,138–1,153	Basalt, massive, very dense, aphanitic—very fine crystalline (diktytaxitic), small numerous horizontal vesicle streams, black (5YR 2.5/1) mottled bluish gray (GLEY2 4/1), fractured in part, white calcite filling in fractures
1,153–1,178	Basalt, massive, very dense, medium strong to strong, brittle, very fine crystalline, dark bluish gray (5B 4/1), fractures and vesicles healed with white calcite
1,178–1,179	Basalt, massive, very dense, medium strong to strong, brittle, very fine crystalline, dark bluish gray (5B 4/1)
1,179	Total Depth Cored

Appendix B

General Well Information Forms and Instrumentation Table for MIDDLE-2050, MIDDLE-2050A, and MIDDLE-2051

GENERAL WELL INFORMATION

REQUIRED INFORMATION

Well Name:	MIDDLE-2050	Point of Contact/Well Owner:	Mike Hodel, Erick Neheer, Tom Wood
Facility:	INL-CFA Area	Field Team Leader:	Lori Lopez and Troy Buxton
Project:	Drilling, Coring, and Installation of Wells MIDDLE-2050 and MIDDLE-2051 at the INEEL	Geologist:	Gary Oberhansley, Arden Bailey, Erik Whitmore
Well Type:	Exploratory Core Hole/Monitor Well	Drilling Company/Driller:	Major Drilling/ Luis Rosario, Gary Jensen, Dale Gordon
Well Status:	Abandoned	Drilling Method:	Air Rotary and Conventional Coring
Drilling Start Date:	5/24/05 End Date: 6/1/05	Drill Rig:	Foremost DR-24 and UDR-11500 Core Rig
Completion Start Date:	6/1/05 End Date: 7/5/05	Drilling Fluid(s):	Air and Water with Quik-Foam
Total Depth:	385 ft bls	Water Level / Date:	N/A
Completion Depth*:	N/A	Water Level Access:	N/A
* Completion Depth is the lowest accessible depth in the well.		Survey Date: Pending	Surveyor: Pending

Logbook Number and pages where referenced:

ER-056-2005 pp. 12-56, 76-84.

ER-076-2005 pp. 22-24, 155-161, 187.

General Location Description:
Approximately 3/4 mile West of INTEC, 1/2 mile off Lincoln Boulevard along a dirt access road just south of the Big Lost River.

WELL COMPLETION

Borehole Segments

Borehole Diameter	Drill Bit Type	Top (From)	Bottom (To)	Borehole Diameter	Drill Bit Type	Top (From)	Bottom (To)
17 inch	DR Casing Shoe	Surface	54.5 ft	6-inch	CHD-134 Core	70 ft (6 ft of cmt)	385 ft
15 inch	Button Air Hammer	54.5 ft	76 ft				

Casing Segments (include stick up) Note – This does not include Screen – place this info in "Screen" segment.

Top Depth (From)	Bottom Depth (To)	Diameter OD	Diameter ID	Type	Material	Thickness	Hanger Depth	Type	Joint Type
Surface	76 ft	12 3/4 inch	12 inch	Surface	Carbon Steel	Schedule 40			Flush threaded

SCREEN

Top Depth (From)	Bottom Depth (To)	Diameter OD	Diameter ID	Type	Material	Slot Size	Joint Type
N/A							

Annular Seal / Filter Pack

Top Depth (From)	Bottom Depth (To)	Annular Seal	Filter Pack	Material (Be specific as to the type of material)	Placement Method	Mixture / Volume
70 ft	76 ft	☐	☐	Portland Cement Grout mixed with water	Wet-Tremie	9, 92.6-lb bags/~65 gal.
Surface	70 ft	√	☐	Granular bentonite (Casing Seal)	Poured dry down annular & 12 3/4 csg	54, 50-lb bags
2 ft	385 ft	√	☐	Chip bentonite (Hole Plug)	Dry-annulus & 134 rods	157, 50-lb bags
Surface	2 ft	☐	☐	Aggregate Concrete plug	Poured wet	2 ft inside 12 3/4 in. csg

All measurements of depth must be in relation to the land surface (bls).

GENERAL WELL INFORMATION

INSTRUMENTATION

Instrument Type Description	Instrument Name	Instrument Depth	Carrier Pipe Description	Carrier Pipe Top (From)	Carrier Pipe Bottom (To)
N/A					

Comments: This borehole/corehole was plugged and abandoned because of the core bit, barrel and core rods becoming stuck down the corehole, due to sloughing sediments from above interbeds. The corehole was back reamed from the total depth cored at 385 ft bls to 295.5 ft bls, where the core string became stuck (rock locked). The 134 (PQ) core rods were cut off down hole at 274.5 ft bls with the upper sections of core rods being removed from the corehole. The core bit, outer core barrel, sub and reamer/stabilizer, and approximately 9 ft of 134 (PQ) core rod were left in the corehole (the total length being 21 ft).

All measurements of depth must be in relation to the land surface (bls).

GENERAL WELL INFORMATION

WELL DEVELOPMENT

Pump Specifications

Type:	N/A
Manufacture:	
Model No.:	
Top Depth of Pump:	
Bottom Depth of Pump:	
Intake/Inlet Depth:	
Horse Power:	
Flow Rate:	
Head:	
Volts, Amps, KW:	
Phase:	
Motor Leads Submersible Cable:	Connections covered with plastic heat shrink seal

Be Sure To Note Access Line Information:

N/A

Well Development

Date: N/A Comments:	Method: N/A

Pump Test

Date: N/A Comments:	Specific Capacity: N/A

Brass Cap Location (This can be separate but must be from Ken Beard / Bob Sutherland)

Northing Datum 27:	Not available	Northing Datum 83:	Not available
Easting Datum 27:		Easting Datum 83:	
Latitude Datum 27:		Latitude Datum 83:	
Longitude Datum 27:		Longitude Datum 83:	
Elevation Datum 29:		Elevation Datum 88:	

Measuring Point Location

Northing Datum 27:	Not available	Northing Datum 83:	Not available
Easting Datum 27:		Easting Datum 83:	
Latitude Datum 27:		Latitude Datum 83:	
Longitude Datum 27:		Longitude Datum 83:	
Elevation Datum 29:		Elevation Datum 88:	

Geophysical Logging

Be sure to turn in Logs so they can be added to the diagrams. Make sure video recordings are turned in to the HDR

	Tool	Date		Tool	Date
	Gamma-Gamma			Natural Gamma	
	Neutron		√	Video	6/13/05
	Caliper			Deviation	
Other Logs and Dates:					

Comments: The down-hole camera used for this video was a small portable camera for onsite down-hole observation. On 6/13/05 the corehole was videoed using an onsite TV/recorder and recorded on the USGS video of MIDDLE-2050A, recorded on 6/9/05. The camera was run along side of a measuring tag line for true down-hole depth. It was ran to approximately 310.5 ft bls where visual contact was lost because of foam in the corehole. The top of the 134 (PQ) that was rod cut off and left in the corehole was observed at 274.5 ft bls. The top of the outer core barrel, sub and reamer/stabilizer was observed at 285.5 ft bls. The bottom of the CHD 134 core bit was at 295.5 ft bls.

All measurements of depth must be in relation to the land surface (bls).

GENERAL WELL INFORMATION

REQUIRED INFORMATION

Well Name:	MIDDLE-2050A	Point of Contact/Well Owner:	Mike Hodel, Erick Neheer, Tom Wood
Facility:	INL-CFA	Field Team Leader:	Lori Lopez and Troy Buxton
Project:	Drilling, Coring, and Installation of Wells MIDDLE-2050 and MIDDLE-2051 at the INEEL	Geologist:	Gary Oberhansley, Arden Bailey, Erik Whitmore
Well Type:	Exploratory Core Hole/Monitor Well	Drilling Company/Driller:	Major Drilling/ Luis Rosario, Gary Jensen, Dale Gordon
Well Status:	Active Multilevel Monitoring Well	Drilling Method:	Air Rotary and Conventional Coring
Drilling Start Date:	5/24/05 End Date: 7/1/05	Drill Rig:	Foremost DR-24 and UDR-11500 Core Rig
Completion Start Date:	7/1/05 End Date: 9/27/05	Drilling Fluid(s):	Air and Water with Quik-Foam
Total Depth:	1427.4 ft bls	Water Level / Date:	481 ft bls / 7-19-05
Completion Depth*:	1376 ft bls	Water Level Access:	MP casing (100mm PVC)
* Completion Depth is the lowest accessible depth in the well.		Survey Date: Pending	Surveyor: Pending

Logbook Number and pages where referenced: ER-056-2005 pp. 56-153, 187.
ER-076-2005 pp. 12-90, 163-169, 189.
ER-007-2005 pp. 1-29.

General Location Description:
Approximately 3/4 mile West of INTEC, 1/2 mile off Lincoln Boulevard along a dirt access road just south of the Big Lost River. This corehole location is also approximately 32 ft N 25° E of the original MIDDLE-2050 location.

WELL COMPLETION

Borehole Segments

Borehole Diameter	Drill Bit Type	Top (From)	Bottom (To)	Borehole Diameter	Drill Bit Type	Top (From)	Bottom (To)
17 inch	DR Casing Shoe	Surface	55.5 ft	6-inch	CHD-134 Core	420 ft	1333 ft
15 inch	Button Air Hammer	55.5 ft	71 ft	5 3/4 inch	Tri-cone	1333 ft	1417 ft
13 inch	Button Air Hammer	71 ft	420 ft	5.5-inch	CHD-134 Core	1417 ft	1427.4 ft
				5 3/4 inch	Tri-cone	1417 ft (reamed)	1422 ft (reamed)

Casing Segments (include stick up) Note – This does not include Screen – place this info in "Screen" segment.

Top Depth (From)	Bottom Depth (To)	Diameter OD	Diameter ID	Type	Material	Thickness	Hanger Depth	Type	Joint Type
+2.9 ft	71 ft	12 3/4 inch	12 inch	Surface	Carbon Steel	Schedule 40			Flush threaded
+2.2 ft	420 ft	6 5/8 inch	6 1/8 inch	Well	Carbon Steel	Schedule 40			Flush threaded

SCREEN

Top Depth (From)	Bottom Depth (To)	Diameter OD	Diameter ID	Type	Material	Slot Size	Joint Type
N/A							

All measurements of depth must be in relation to the land surface (bls).

GENERAL WELL INFORMATION

Annular Seal / Filter Pack

Top Depth (From)	Bottom Depth (To)	Annular Seal	Filter Pack	Material (Be specific as to the type of material)	Placement Method	Mixture / Volume
Surface	71 ft	√		Chip bentonite (Hole Plug) Granular bentonite (Casing Seal)	Dry-Tremie between csg and annulus	308 50-lb bags 173 50-lb bags
Surface	420 ft	√		Chip bentonite (Hole Plug) Granular bentonite (Casing Seal)	Dry-Tremie between csg and annulus	From same volume above
1379 ft	1418.7 ft			6X9 Colorado Sand	Open hole	6 50-lb bags
1418.7 ft	1427.4 ft			Fill	Caving/sloughing	8.7 ft fill

INSTRUMENTATION

Instrument Type Description	Instrument Name	Instrument Depth	Carrier Pipe Description	Carrier Pipe Top (From)	Carrier Pipe Bottom (To)

Comments: Westbay Instruments installed a MP55 multilevel interval system (packers, MP measurement ports and casing) to the open corehole Middle-2050A, for a monitoring well completion. See: Completion Report for Westbay MP55 Multilevel Monitoring Wells: Middle-2050A, Middle-2051, Idaho Falls, Idaho (located in Appendix F).

WELL DEVELOPMENT

Pump Specifications

Type:	Not available
Manufacture:	Grunfos
Model No.:	Not available
Top Depth of Packer:	635.5 ft, 975.2 ft, 648.5 ft, 1090.5 ft, 1195.5 ft
Bottom Depth of Pump:	648 ft, 987.7 ft, 661 ft, 1103 ft, 1208 ft
Intake/Inlet Depth:	645.5-645.3 ft, 985.2-985 ft, 658.5-658.7 ft, 1100.5-1100.7 ft, 1205.6-1205.3 ft
Horse Power:	10
Flow Rate:	28 USGMP
Head:	Not available
Volts, Amps, KW:	Not available
Phase:	Not available
Motor Leads Submersible Cable:	Connections covered with plastic heat shrink seal

Well Development

Date: 7/7/05-7/12/05 Comments: Developed with a temporary pump/motor and packer, using an auxiliary generator.	Method: First interval (645.5-645.3 ft) pumped 1260 gal wtr Second interval (985.2-985 ft) pumped 495 gal wtr Third interval (658.5-658.7 ft) pumped 50 gal wtr Forth interval (1100.5-1100.7 ft) pumped 884 gal wtr Fifth interval (1205.6-1205.3 ft) pumped 2210 gal wtr Total water produce during development = 4899 gal 7/13/05-7/20/05 Total water produce during initial sampling = 33,585 gal (Total produce water in well to date = 38484 gal)

Pump Test

Date: 7/11/05-7/12/05 Comments: 1st-Water initially clear. 2nd- Water initially clear 3rd- Water initially clear 4th- Water initially murky yellowish brown-clearing quickly 5th- Water initially slightly murky yellowish brown-clearing quickly	Specific Capacity: First interval-water to surface in 1.3 min. at 28 gpm Second interval-water to surface in 1.5 min. at 26 gpm Third interval-water to surface in 1.5 min. at 26 gpm Forth interval-water to surface in 1.7 min. at 26 gpm Fifth interval-water to surface in 1.7 min. at 26 gpm

Be Sure To Note Access Line Information: Note: MP casing (100mm PVC) used for access line.

All measurements of depth must be in relation to the land surface (bls).

GENERAL WELL INFORMATION

Brass Cap Location (This can be separate but must be from Ken Beard / Bob Sutherland)

Northing Datum 27:	Not available	Northing Datum 83:	Not available
Easting Datum 27:		Easting Datum 83:	
Latitude Datum 27:		Latitude Datum 83:	
Longitude Datum 27:		Longitude Datum 83:	
Elevation Datum 29:		Elevation Datum 88:	

Measuring Point Location

Northing Datum 27:	Not available	Northing Datum 83:	Not available
Easting Datum 27:		Easting Datum 83:	
Latitude Datum 27:		Latitude Datum 83:	
Longitude Datum 27:		Longitude Datum 83:	
Elevation Datum 29:		Elevation Datum 88:	

Geophysical Logging

Be sure to turn in Logs so they can be added to the diagrams. Make sure video recordings are turned in to the HDR

√	Tool	Date	√	Tool	Date
√	Gamma-Gamma	7/5/05, 7/6/05	√	Natural Gamma	6/9/05, 7/5/05, 9/15/05
√	Neutron	7/5/05, 7/6/05	√	Video	6/9/05, 7/5/05, 9/6/05
√	Caliper	6/9/05, 7/5/05, 9/15/05	√	Deviation	7/5/05, 8/25/05
√	Temperature	7/5/05	√	Flow Rate	9/8/05
√	Resistivity	7/5/05			
Other Logs and Dates:					
Comments: All above log runs were made by the USGS. Both electronic and hard copies were given to the onsite geologist, along with recordings of their down hole camera runs. An onsite portable camera was used often for down hole observations and troubleshooting. No recordings were made on this well by that camera.					

GENERAL WELL INFORMATION

REQUIRED INFORMATION

Well Name:	MIDDLE-2051	Point of Contact/Well Owner:	Mike Hodel, Erick Neher, and Tom Wood
Facility:	INL-CFA	Field Team Leader:	Lori Lopez and Troy Buxton
Project:	Drilling, Coring, and Installation of Wells MIDDLE-2050 and MIDDLE-2051 at the INEEL	Geologist:	Gary Oberhansley, Arden Bailey, and Erik Whitmore
Well Type:	Exploratory Core Hole/Monitor Well	Drilling Company/Driller:	Major Drilling/Luis Rosario, Gary Jensen, and Dale Gordon
Well Status:	Active Multilevel Monitoring Well	Drilling Method:	Air Rotary and Conventional Coring
Drilling Start Date:	1/19/05 End Date: 5/18/05	Drill Rig:	Foremost DR-24 and UDR-11500 Core Rig
Completion Start Date:	5/18/05 End Date: 10/3/05	Drilling Fluid(s):	Air and Water with Quik-Foam
Total Depth:	1,179 ft bls	Water Level / Date:	571 ft bls/8-18-05
Completion Depth*:	1,177 ft bls	Water Level Access:	MP casing (100 mm PVC)
* Completion Depth is the lowest accessible depth in the well.		Survey Date: Pending	Surveyor: Pending

Logbook Number and pages where referenced: ER-011-2005, pp. 12–153, 187

ER-010-2005, pp. 12–70, 155–161

ER-007-2005, pp. 1–29

General Location Description:
The corehole/well location is 1-1/4 mile south of US Highway 20 on T-12 road, just south of Big Lost River, and 2-3/4 miles northeast of RWMC.

WELL COMPLETION

Borehole Segments

Borehole Diameter	Drill Bit Type	Top (From)	Bottom (To)	Borehole Diameter	Drill Bit Type	Top (From)	Bottom (To)
16.5 inch	DR Casing Shoe	Surface	107 ft	6 inch	CHD-134 Core	92 ft (34.7 ft cmt)	1,179 ft
15 inch	Button Air Hammer	107 ft	126.7 ft	10-3/4 inch	Button Air Hammer	92 ft (reamed)	430 ft (reamed)

Casing Segments (include stick up) Note – This does not include Screen – place this info in "Screen" segment.

Top Depth (From)	Bottom Depth (To)	Diameter OD	Diameter ID	Type	Material	Thickness	Hanger Depth	Type	Joint Type
Surface	107 ft	16 inch	15 3/4 inch	Temporary DR	Carbon Steel	Schedule 40			Flush threaded
+3.1 ft	126.7 ft	12 3/4 inch	12 inch	Surface	Carbon Steel	Schedule 40			Flush threaded
+2.3 ft	430.5 ft	6 5/8 inch	6 1/8 inch	Well	Carbon Steel	Schedule 40			Flush threaded

SCREEN

Top Depth (From)	Bottom Depth (To)	Diameter OD	Diameter ID	Type	Material	Slot Size	Joint Type
N/A							

Annular Seal / Filter Pack

Top Depth (From)	Bottom Depth (To)	Annular Seal	Filter Pack	Material (Be specific as to the type of material)	Placement Method	Mixture / Volume
92 ft	126.7 ft			Portland Cement Grout mixed with water	Wet-Tremie inside 12 3/4 inch csg	9 92.6-lb bags/~65 gal.
99 ft	126.7 ft			Portland Cement Grout mixed with water	Wet-Tremie between csg and annulus	From same mixture above

All measurements of depth must be in relation to the land surface (bls).

GENERAL WELL INFORMATION

Surface	99 ft	√		Chip bentonite (Hole Plug)	Dry-Tremie between 16 & 12 3/4 in. casing	44 50-lb bags
Top Depth (From)	Bottom Depth (To)	Annular Seal	Filter Pack	Material (Be specific as to the type of material)	Placement Method	Mixture / Volume
389.5 ft	430.5 ft			Portland Cement Grout mixed with water	Wet-Tremie between 6 5/8 in, csg & annulus	30 92.6-lb bags/~300 gal.
Surface	389.5 ft	√		Chip bentonite (Hole Plug)	Dry-Tremie between 12 3/4 & 6 5/8 in. csg	225 50-lb bags

INSTRUMENTATION

Instrument Type Description	Instrument Name	Instrument Depth	Carrier Pipe Description	Carrier Pipe Top (From)	Carrier Pipe Bottom (To)

Comments: This borehole/corehole was completed by Westby Instruments Inc. using a multilevel MP casing (100mm PVC), packer, pumping port and measurement port system for installation of a MP55 multilevel monitoring well. See Completion Report MP55 Monitoring Wells: Middle 2050A, Middle-2051 Idaho Falls, Idaho (located in Appendix F).

Note: While air drilling the surface soils and underlying alluvial sands and gravels, a large void develop on the outside of the 16-inch DR casing, just below the frozen surface soils. Caving and funneling loose sands and gravels down the advancing borehole and casing, which were blown out of the borehole as cuttings at the bit and cutting shoe interface, caused this void. Surface caving at the back of the drill rig along the back jack stabilizers occurred while attempting to pull the 16-inch DR casing from the borehole. To keep the surface soils from caving 65 50-lb bags of Hole Plug bentonite and 14 50-lb bags of Casing Seal bentonite where used to fill the void space.

WELL DEVELOPMENT

Pump Specifications

Type:	Not available
Manufacture:	Grunfos
Model No.:	Not available
Top Depth of Packer:	1136 ft, 988.7 ft, 778.3 ft, 756 ft, 585 ft
Bottom Depth of Pump:	1149 ft, 1001.7 ft, 788 ft, 743 ft, 595.2 ft
Intake/Inlet Depth:	1146.5-1146.3 ft, 999.2-999.0 ft, 785.5-785.3 ft, 740.5-740.3 ft, 589.7-589.5 ft
Horse Power:	10, 5
Flow Rate:	26 USGPM, 18 USGPM
Head:	Not available
Volts, Amps, KW:	Not available
Phase:	Not available
Motor Leads Submersible Cable:	Connections covered with plastic heat shrink seal

Well Development

Date: 7/26/05-8/2/05	Method: First interval (1146.5-1146.3 ft) pumped 4070 gal wtr Second interval (999.2-999.0 ft) pumped 2926 gal wtr Third interval (785.5-785.3 ft) pumped 2555 gal wtr Forth interval (740.5-740.3 ft) pumped 4420 gal wtr Fifth interval 589.7-589.5 ft) pumped 4501 gal wtr Total water produce during sampling = 18,472 gal Total water produce during initial sampling = 18,472 gal (Total produce water in well to date = 18,472 gal)
Comments: There was no predevelopment in this well. Sampled with a temporary pump/motor and packer, using an auxiliary generator.	

Pump Test

Date: 7/11/05-7/12/05	Specific Capacity: First interval-water to surface in 2.1 min. at 22 gpm Second interval-water to surface in 2 min. at 22 gpm Third interval-water to surface in 2.3 min. at 16.7 gpm Forth interval-water to surface in 2.2 min. at 17 gpm Fifth interval-water to surface in 2.2 min. at 17.5 gpm
Comments: 1st-Water rusty, slightly soapy clearing quickly 2nd- Water initially clear 3rd- Water rusty/murky, slightly soapy clearing quickly 4th- Water rusty, clearing quickly 5th- Water rusty/murky, slightly soapy clearing quickly	

Be Sure To Note Access Line Information: Note: MP casing (100mm PVC) used as access line.

All measurements of depth must be in relation to the land surface (bls).

GENERAL WELL INFORMATION

Brass Cap Location (This can be separate but must be from Ken Beard / Bob Sutherland)

Northing Datum 27:	Not available	Northing Datum 83:	Not available
Easting Datum 27:		Easting Datum 83:	
Latitude Datum 27:		Latitude Datum 83:	
Longitude Datum 27:		Longitude Datum 83:	
Elevation Datum 29:		Elevation Datum 88:	

Measuring Point Location

Northing Datum 27:	Not available	Northing Datum 83:	Not available
Easting Datum 27:		Easting Datum 83:	
Latitude Datum 27:		Latitude Datum 83:	
Longitude Datum 27:		Longitude Datum 83:	
Elevation Datum 29:		Elevation Datum 88:	

Geophysical Logging

Be sure to turn in Logs so they can be added to the diagrams. Make sure video recordings are turned in to the HDR

√	Tool	Date	√	Tool	Date
√	Gamma-Gamma	5/18/05	√	Natural Gamma	4/22/05, 5/23/05, 5/25/05, 8/18/05
√	Neutron	5/18/05	√	Video	5/23/05, 5/25/05, 8/18/05
√	Caliper	4/22/05, 5/23/05, 5/25/05	√	Deviation	5/18/05
	Temperature	5/18/05, 5/23/05, 5/25/05, 8/18/05		Flow Rate	8/18/05
	Resistivity	5/25/05			
Other Logs and Dates:					
Comments: All above log runs were made by the USGS. Both electronic and hard copies were given to the onsite geologist, along with recordings of their down hole camera runs. An onsite portable camera was used often for down hole observations and troubleshooting. No recordings were made on this well by that camera.					

All measurements of depth must be in relation to the land surface (bls).

WELL_NAME	WELL_ID	DATE_REC_ UPDATED	INSTRUMENT_ TYPE	R_INSTRUMENT_ TYPE	INSTRUMENT_ NAME	R_INSTRUMENT_ NAME	INSTRUMENT_ DEPTH_BLS (FT)	R_INSTRUMENT_ DEPTH_BLS	CARRIER_PIPE_ MATERIAL	R_CARRIER_ PIPE_MATERIAL	CARRIER_PIPE_ DIAMETER (IN)	R_CARRIER_ PIPE_DIAMETER	CARRIER_PIPE_ TOP_DEPTH_BL	R_CARRIER_PIPE_ TOP_DEPTH	CARRIER_PIPE_ BOTTOM_DEPTH	R_CARRIER_PIPE_ BOTTOM_DEP
MIDDLE-2050	2137		NF	115	NF	115	NF	115	NF	115		115		115		115
MIDDLE-2050A	2050		WB QA-Measuring Port	378	2050A-252.1-QAMP	378	252.1	378	NF	115		115		115		115
MIDDLE-2050A	2050		WB Measuring Port	378	2050A-463.6-MP	378	463.6	378	NF	115		115		115		115
MIDDLE-2050A	2050		WB Measuring Port	378	2050A-514.9-MP	378	514.9	378	NF	115		115		115		115
MIDDLE-2050A	2050		WB Pumping Port	378	2050A-525.2-PP	378	525.2	378	NF	115		115		115		115
MIDDLE-2050A	2050		WB QA-Measuring Port	378	2050A-540.2-QAMP	378	540.2	378	NF	115		115		115		115
MIDDLE-2050A	2050		WB QA-Measuring Port	378	2050A-622.2-QAMP	378	622.2	378	NF	115		115		115		115
MIDDLE-2050A	2050		WB Measuring Port	378	2050A-641.9-MP	378	641.9	378	NF	115		115		115		115
MIDDLE-2050A	2050		WB Pumping Port	378	2050A-652.1-PP	378	652.1	378	NF	115		115		115		115
MIDDLE-2050A	2050		WB QA-Measuring Port	378	2050A-704.9-QAMP	378	704.9	378	NF	115		115		115		115
MIDDLE-2050A	2050		WB QA-Measuring Port	378	2050A-718.0-QAMP	378	718.0	378	NF	115		115		115		115
MIDDLE-2050A	2050		WB Measuring Port	378	2050A-790.2-MP	378	790.2	378	NF	115		115		115		115
MIDDLE-2050A	2050		WB Pumping Port	378	2050A-800.5-PP	378	800.5	378	NF	115		115		115		115
MIDDLE-2050A	2050		WB QA-Measuring Port	378	2050A-809.0-QAMP	378	809.0	378	NF	115		115		115		115
MIDDLE-2050A	2050		WB QA-Measuring Port	378	2050A-841.7-QAMP	378	841.7	378	NF	115		115		115		115
MIDDLE-2050A	2050		WB Measuring Port	378	2050A-997.6-MP	378	997.6	378	NF	115		115		115		115
MIDDLE-2050A	2050		WB Pumping Port	378	2050A-1007.9-PP	378	1007.9	378	NF	115		115		115		115
MIDDLE-2050A	2050		WB QA-Measuring Port	378	2050A-1042.6-QAMP	378	1042.6	378	NF	115		115		115		115
MIDDLE-2050A	2050		WB QA-Measuring Port	378	2050A-1080.3-QAMP	378	1080.3	378	NF	115		115		115		115
MIDDLE-2050A	2050		WB Measuring Port	378	2050A-1178.8-MP	378	1178.8	378	NF	115		115		115		115
MIDDLE-2050A	2050		WB Pumping Port	378	2050A-1189.1-PP	378	1189.1	378	NF	115		115		115		115
MIDDLE-2050A	2050		WB QA-Measuring Port	378	2050A-1228.7-QAMP	378	1228.7	378	NF	115		115		115		115
MIDDLE-2050A	2050		WB QA-Measuring Port	378	2050A-1266.5-QAMP	378	1266.5	378	NF	115		115		115		115
MIDDLE-2051	2051		WB QA-Measuring Port	378	2051-293.7-QAMP	378	293.7	378	NF	115		115		115		115
MIDDLE-2051	2051		WB Measuring Port	378	2051-563.7-MP	378	563.7	378	NF	115		115		115		115
MIDDLE-2051	2051		WB Measuring Port	378	2051-604.2-MP	378	604.2	378	NF	115		115		115		115
MIDDLE-2051	2051		WB Pumping Port	378	2051-593.7-PP	378	593.7	378	NF	115		115		115		115
MIDDLE-2051	2051		WB QA-Measuring Port	378	2051-614.1-QAMP	378	614.1	378	NF	115		115		115		115
MIDDLE-2051	2051		WB QA-Measuring Port	378	2051-648.5-QAMP	378	648.5	378	NF	115		115		115		115
MIDDLE-2051	2051		WB Measuring Port	378	2051-750.1-MP	378	750.1	378	NF	115		115		115		115
MIDDLE-2051	2051		WB Pumping Port	378	2051-760.4-PP	378	760.4	378	NF	115		115		115		115
MIDDLE-2051	2051		WB QA-Measuring Port	378	2051-775.4-QAMP	378	775.4	378	NF	115		115		115		115
MIDDLE-2051	2051		WB QA-Measuring Port	378	2051-793.4-QAMP	378	793.4	378	NF	115		115		115		115
MIDDLE-2051	2051		WB Measuring Port	378	2051-827.8-MP	378	827.8	378	NF	115		115		115		115
MIDDLE-2051	2051		WB Pumping Port	378	2051-838.1PP	378	838.1	378	NF	115		115		115		115
MIDDLE-2051	2051		WB QA-Measuring Port	378	2051-881.0-QAMP	378	881.0	378	NF	115		115		115		115

(continued).

WELL_NAME	WELL_ID	DATE_REC_ UPDATED	INSTRUMENT_ TYPE	R_INSTRUMENT_ TYPE	INSTRUMENT_ NAME	R_INSTRUMENT_ NAME	INSTRUMENT_ DEPTH_BLS (FT)	R_INSTRUMENT_ DEPTH_BLS	CARRIER_PIPE_ MATERIAL	R_CARRIER_ PIPE_MATERIAL	CARRIER_PIPE_ DIAMETER (IN)	R_CARRIER_ PIPE_DIAMETER	CARRIER_PIPE_ TOP_DEPTH_BL	R_CARRIER_PIPE_ TOP_DEPTH	CARRIER_PIPE_ BOTTOM_DEPTH	R_CARRIER_PIPE_ BOTTOM_DEP
MIDDLE-2051	2051		WB QA-Measuring Port	378	2051-1004.0-QAMP	378	1004.0	378	NF	115		115		115		115
MIDDLE-2051	2051		WB Measuring Port	378	2051-1092.5-MP	378	1092.5	378	NF	115		115		115		115
MIDDLE-2051	2051		WB Pumping Port	378	2051-1102.8-PP	378	1102.8	378	NF	115		115		115		115
MIDDLE-2051	2051		WB QA-Measuring Port	378	2051-1132.6-QAMP	378	1132.6	378	NF	115		115		115		115
MIDDLE-2051	2051		WB Measuring Port	378	2051-1142.5-MP	378	1142.5	378	NF	115		115		115		115
MIDDLE-2051	2051		WB Pumping Port	378	2051-1152.8-PP	378	1152.8	378	NF	115		115		115		115

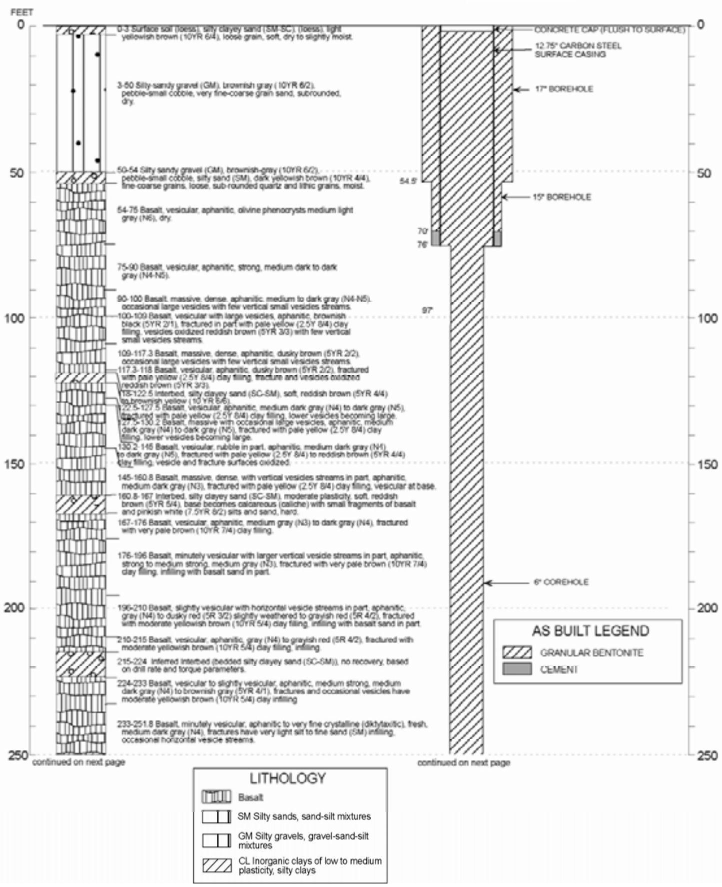
Appendix C

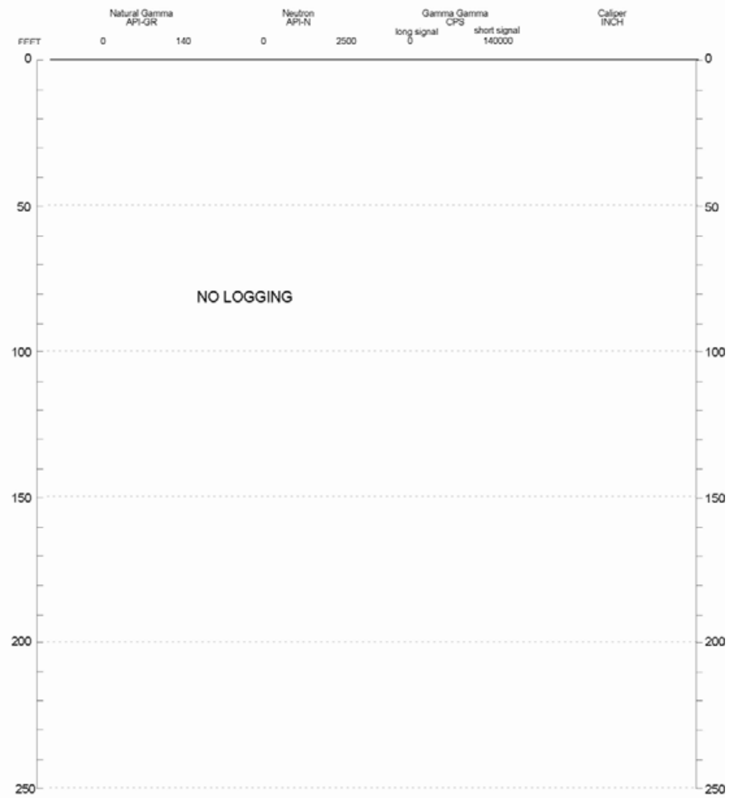
Well Completion Diagrams for MIDDLE-2050, MIDDLE-2050A, and MIDDLE-2051

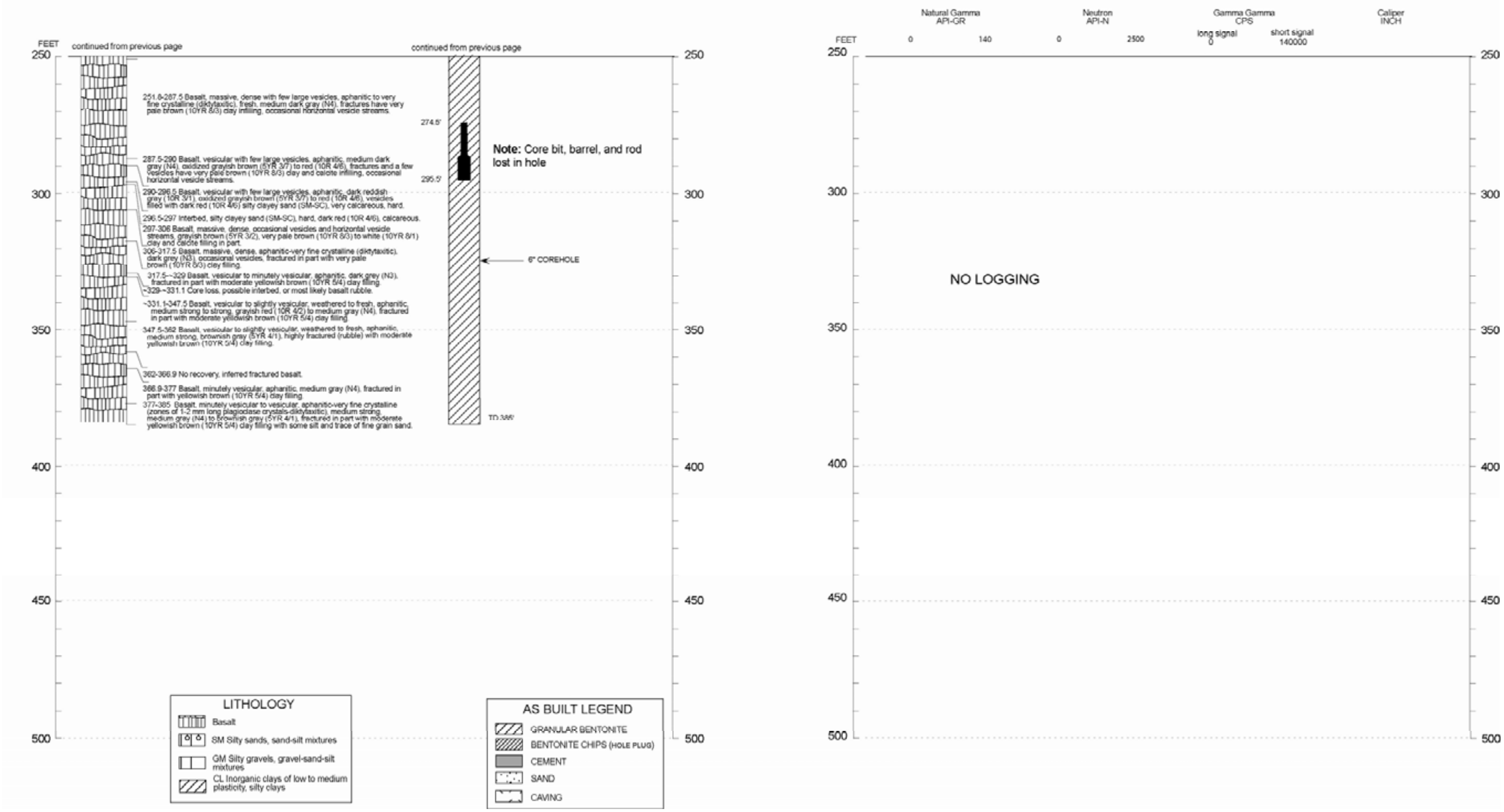
WELL NAME: **MIDDLE-2050**
Facility: INL-CFA Area
Well Type: Exploratory Core Hole/Monitoring
Well Status: Abandoned
Year Drilled: 2005
Total Depth: 385'
Drilling Start Date 5/24/05 End Date 6/1/05
Completion Start Date 6/1/05 End Date 7/5/05
Completion Depth: N/A

Driller: Major Drilling/Rosario, Jensen, Gordon
Geologist: Oberhansley, Bailey, Whitmore
Drill Method: Air Rotary/ Conventional Coring
Drill Fluid: Air/QuickFoam/Water
Elevation: (29 BC) (29 MP) (88 BC) (88MP)

Todays Date: 1/10/06
Water Level: N/A
Water Level Date: N/A
Water Level Access: N/A






FEET
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251.8-287.5 Basalt, massive, dense with few large vesicles, aphanitic to very fine crystalline (diktytaxitic), fresh, medium dark gray (N4), fractures have very pale brown (10YR 8/3) clay infilling, occasional horizontal vesicle streams.
287.5-290 Basalt, vesicular with few large vesicles, aphanitic, medium dark gray (N4), oxidized grayish brown (5YR 3/7) to red (10R 4/6), fractures and a few vesicles have very pale brown (10YR 8/3) clay and calcite infilling, occasional horizontal vesicle streams.
290-296.5 Basalt, vesicular with few large vesicles, aphanitic, dark reddish gray (10R 3/1), oxidized grayish brown (5YR 3/7) to red (10R 4/6), vesicles filled with dark red (10R 4/6) silty clayey sand (SM-SC), very calcareous, hard.
296.5-297 Interbed, silty clayey sand (SM-SC), hard, dark red (10R 4/6), calcareous.
297-306 Basalt, massive, dense, occasional vesicles and horizontal vesicle streams, grayish brown (5YR 3/2), very pale brown (10YR 8/3) to white (10YR 8/1) clay and calcite filling in part.
306-317.5 Basalt, massive, dense, aphanitic-very fine crystalline (diktytaxitic), dark grey (N3), occasional vesicles, fractured in part with very pale brown (10YR 8/3) clay filling.
317.5-~329 Basalt, vesicular to minutely vesicular, aphanitic, dark grey (N3), fractured in part with moderate yellowish brown (10YR 5/4) clay filling.
~329-~331.1 Core loss, possible interbed, or most likely basalt rubble.
~331.1-347.5 Basalt, vesicular to slightly vesicular, weathered to fresh, aphanitic, medium strong to strong, grayish red (10R 4/2) to medium gray (N4), fractured in part with moderate yellowish brown (10YR 5/4) clay filling.
347.5-362 Basalt, vesicular to slightly vesicular, weathered to fresh, aphanitic, medium strong, brownish gray (5YR 4/1), highly fractured (rubble) with moderate yellowish brown (10YR 5/4) clay filling.
362-366.9 No recovery, inferred fractured basalt.
366.9-377 Basalt, minutely vesicular, aphanitic, medium gray (N4), fractured in part with yellowish brown (10YR 5/4) clay filling.
377-385 Basalt, minutely vesicular to vesicular, aphanitic-very fine crystalline (zones of 1-2 mm long plagioclase crystals-diktytaxitic), medium strong, medium grey (N4) to brownish grey (5YR 4/1), fractured in part with moderate yellowish brown (10YR 5/4) clay filling with some silt and trace of fine grain sand.
274.5'
295.5'
Note: Core bit, barrel, and rod lost in hole
6" COREHOLE
TD 385'
250
300
350
400
450
500
LITHOLOGY
Basalt
SM Silty sands, sand-silt mixtures
GM Silty gravels, gravel-sand-silt mixtures
CL Inorganic clays of low to medium plasticity, silty clays
AS BUILT LEGEND
GRANULAR BENTONITE
BENTONITE CHIPS (HOLE PLUG)
CEMENT
SAND
CAVING
Natural Gamma
API-GR
0
140
Neutron
API-N
0
2500
Gamma Gamma
CPS
long signal
0
short signal
140000
Caliper
INCH
NO LOGGING

WELL NAME: MIDDLE-2050A

Facility: INL-CFA Area

Well Type: Exploratory Core Hole/Monitoring

Well Status: Active

Year Drilled: 2005

Total Depth: 1427.4'

Drilling Start Date 5/24/05 End Date 7/1/05

Completion Start Date 7/1/05 End Date 9/27/05

Completion Depth: 1376'

Driller: Major Drilling/Rosario, Jensen, Gordon

Geologist: Oberhansley, Bailey, Whitmore

Drill Method: Air Rotary/ Conventional Coring

Drill Fluid: Air/QuickFoam/Water

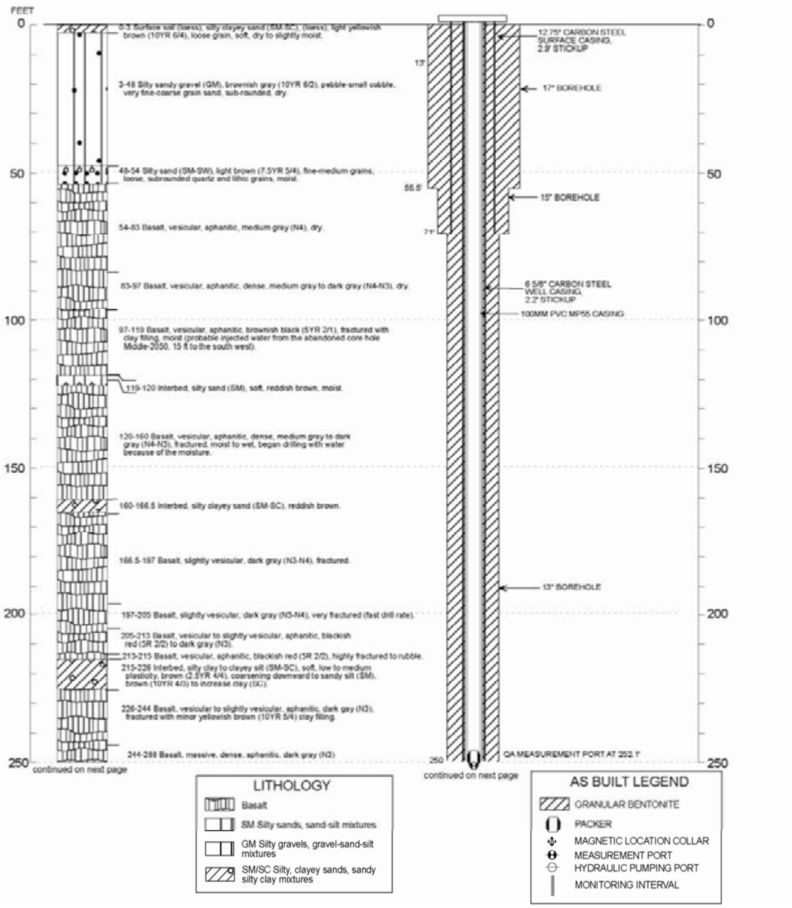
Elevation: (29 BC) (29 MP) (88 BC) (88MP)

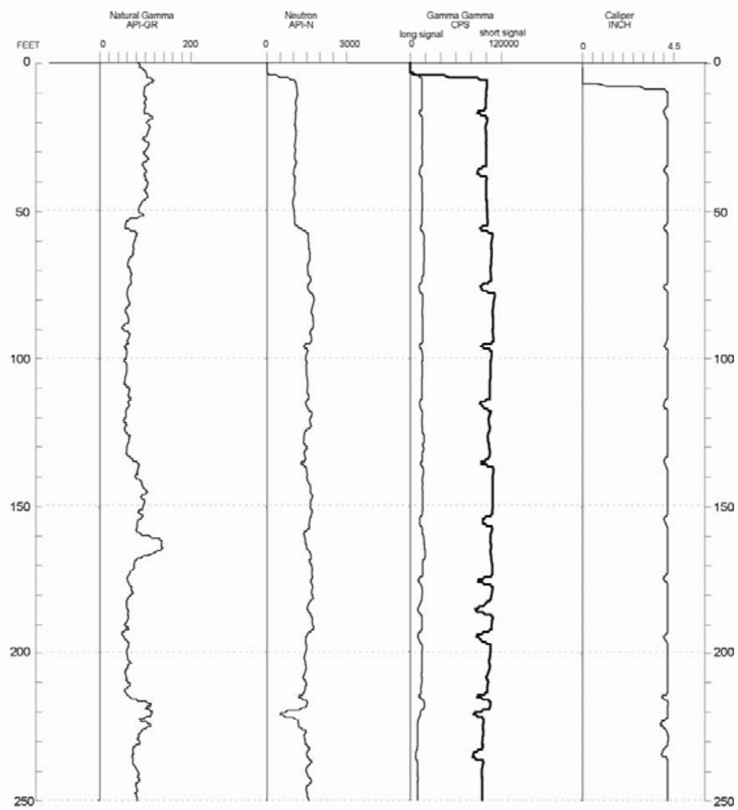
Todays Date: 1/11/06

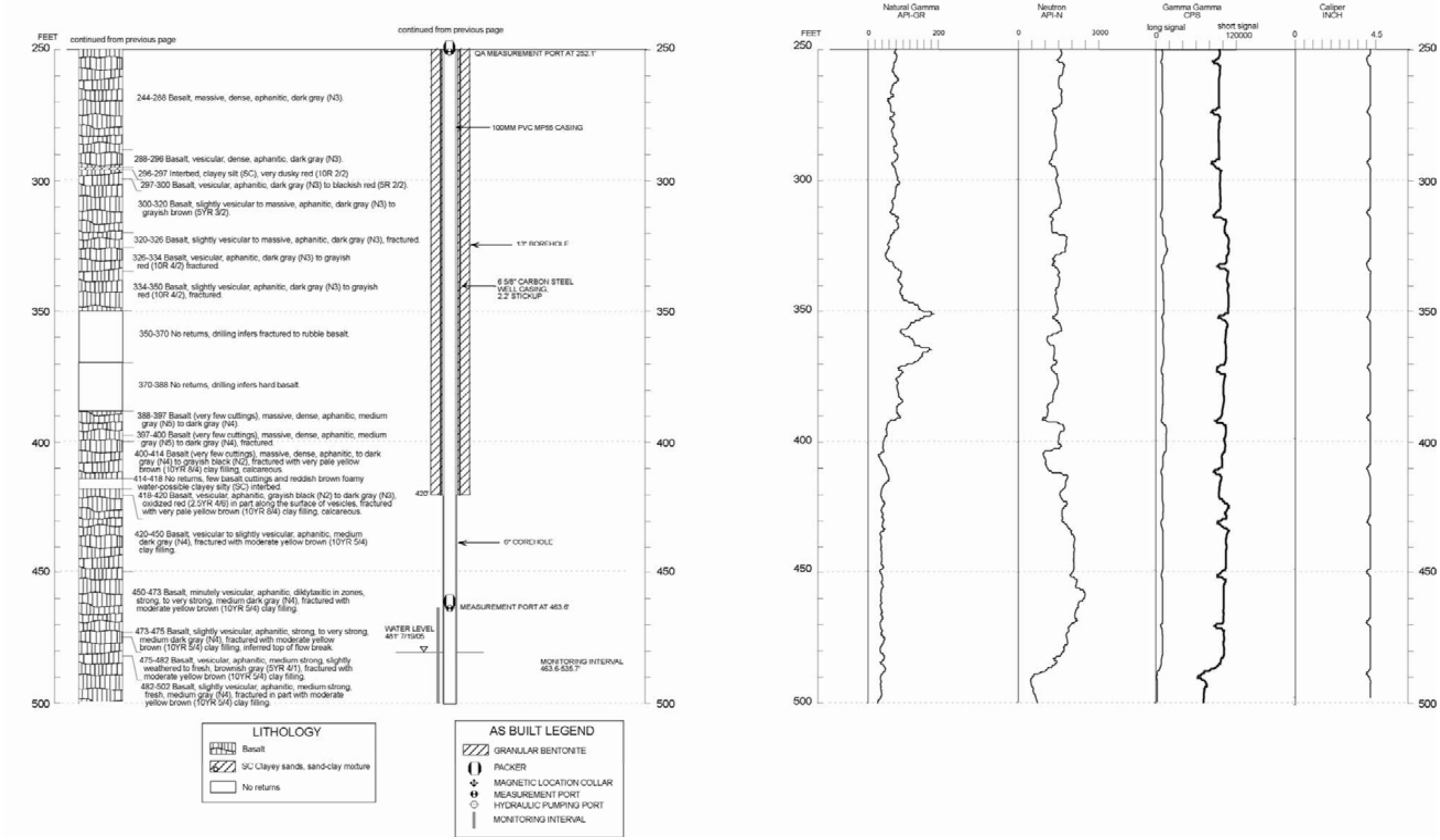
Water Level: 481'

Water Level Date: 7/19/05

Water Level Access: 100mm PVC






FEET
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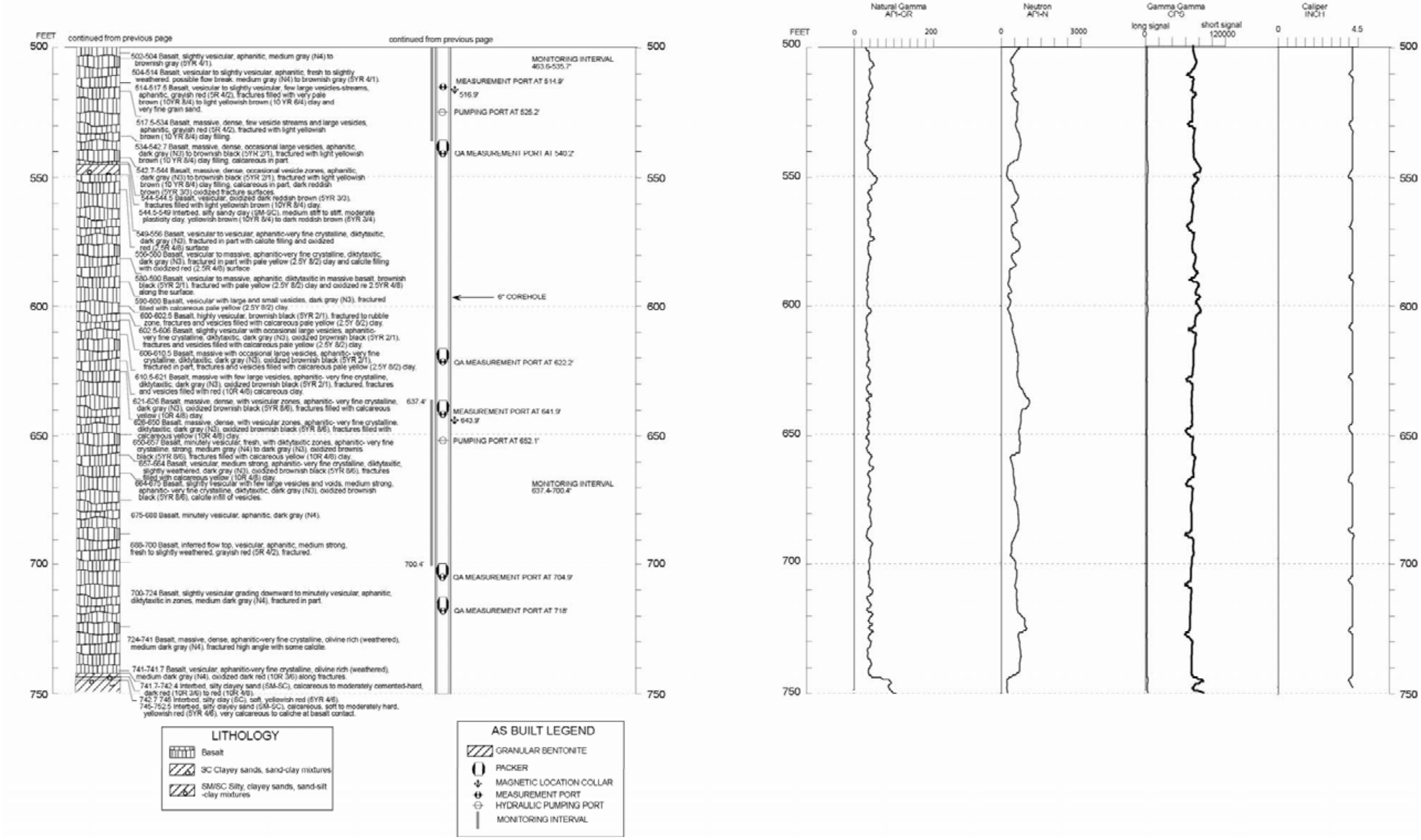
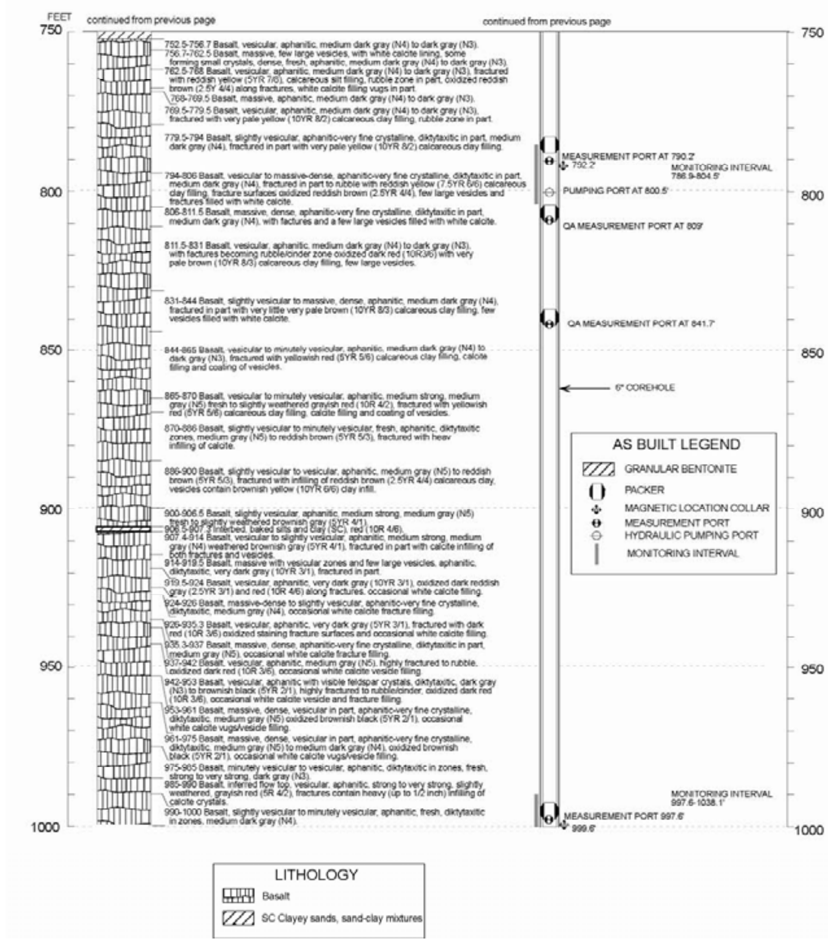
250
300
350
400
450
500
244-288 Basalt, massive, dense, aphanitic, dark gray (N3).
288-296 Basalt, vesicular, dense, aphanitic, dark gray (N3).
296-297 Interbed, clayey silt (SC), very dusky red (10R 2/2)
297-300 Basalt, vesicular, aphanitic, dark gray (N3) to blackish red (5R 2/2).
300-320 Basalt, slightly vesicular to massive, aphanitic, dark gray (N3) to grayish brown (5YR 3/2).
320-326 Basalt, slightly vesicular to massive, aphanitic, dark gray (N3), fractured.
326-334 Basalt, vesicular, aphanitic, dark gray (N3) to grayish red (10R 4/2) fractured.
334-350 Basalt, slightly vesicular, aphanitic, dark gray (N3) to grayish red (10R 4/2), fractured.
350-370 No returns, drilling infers fractured to rubble basalt.
370-388 No returns, drilling infers hard basalt.
388-397 Basalt (very few cuttings), massive, dense, aphanitic, medium gray (N5) to dark gray (N4).
397-400 Basalt (very few cuttings), massive, dense, aphanitic, medium gray (N5) to dark gray (N4), fractured.
400-414 Basalt (very few cuttings), massive, dense, aphanitic, to dark gray (N4) to grayish black (N2), fractured with very pale yellow brown (10YR 8/4) clay filling, calcareous.
414-418 No returns, few basalt cuttings and reddish brown foamy water-possible clayey silty (SC) interbed.
418-420 Basalt, vesicular, aphanitic, grayish black (N2) to dark gray (N3), oxidized red (2.5YR 4/6) in part along the surface of vesicles, fractured with very pale yellow brown (10YR 8/4) clay filling, calcareous.
420-450 Basalt, vesicular to slightly vesicular, aphanitic, medium dark gray (N4), fractured with moderate yellow brown (10YR 5/4) clay filling.
450-473 Basalt, minutely vesicular, aphanitic, diktytaxitic in zones, strong, to very strong, medium dark gray (N4), fractured with moderate yellow brown (10YR 5/4) clay filling.
473-475 Basalt, slightly vesicular, aphanitic, strong, to very strong, medium dark gray (N4), fractured with moderate yellow brown (10YR 5/4) clay filling, inferred top of flow break.
475-482 Basalt, vesicular, aphanitic, medium strong, slightly weathered to fresh, brownish gray (5YR 4/1), fractured with moderate yellow brown (10YR 5/4) clay filling.
482-502 Basalt, slightly vesicular, aphanitic, medium strong, fresh, medium gray (N4), fractured in part with moderate yellow brown (10YR 5/4) clay filling.
continued from previous page
QA MEASUREMENT PORT AT 252.1'
100MM PVC MP55 CASING
12" BOREHOLE
6 5/8" CARBON STEEL WELL CASING, 2.2' STICKUP
420'
6" COREHOLE
MEASUREMENT PORT AT 463.6'
WATER LEVEL 481' 7/19/05
MONITORING INTERVAL 463.6-535.7'
LITHOLOGY
Basalt
SC Clayey sands, sand-clay mixture
No returns
AS BUILT LEGEND
GRANULAR BENTONITE
PACKER
MAGNETIC LOCATION COLLAR
MEASUREMENT PORT
HYDRAULIC PUMPING PORT
MONITORING INTERVAL
Natural Gamma API-GR
0
200
Neutron API-N
0
3000
Gamma Gamma CPS
long signal 0
short signal 120000
Caliper INCH
0
4.5

WELL NAME: **MIDDLE-2050A**




FEET
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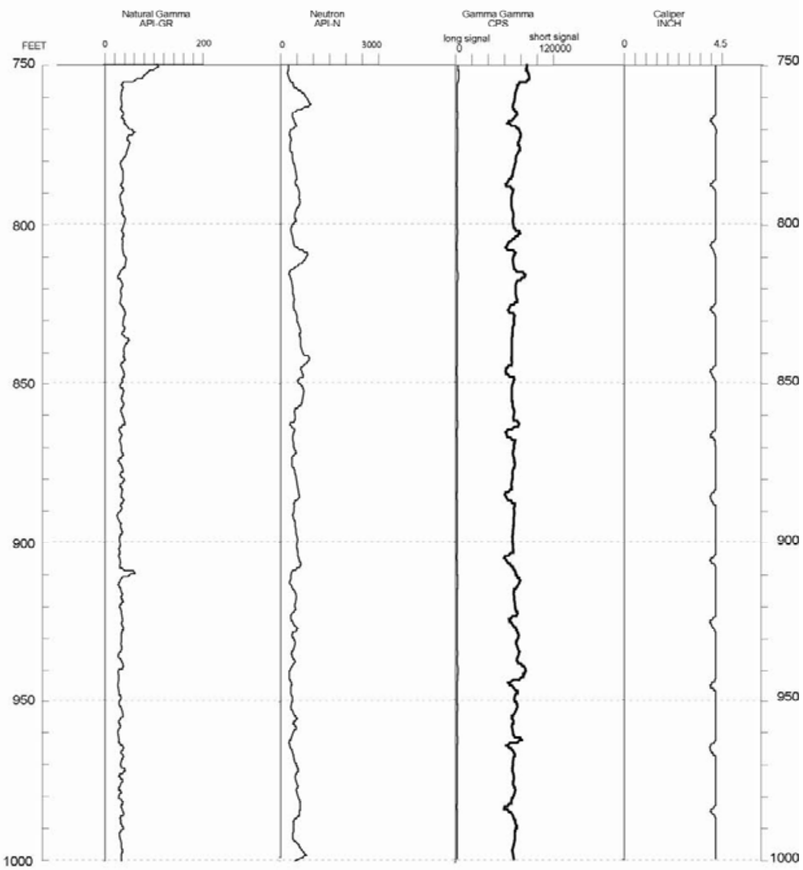
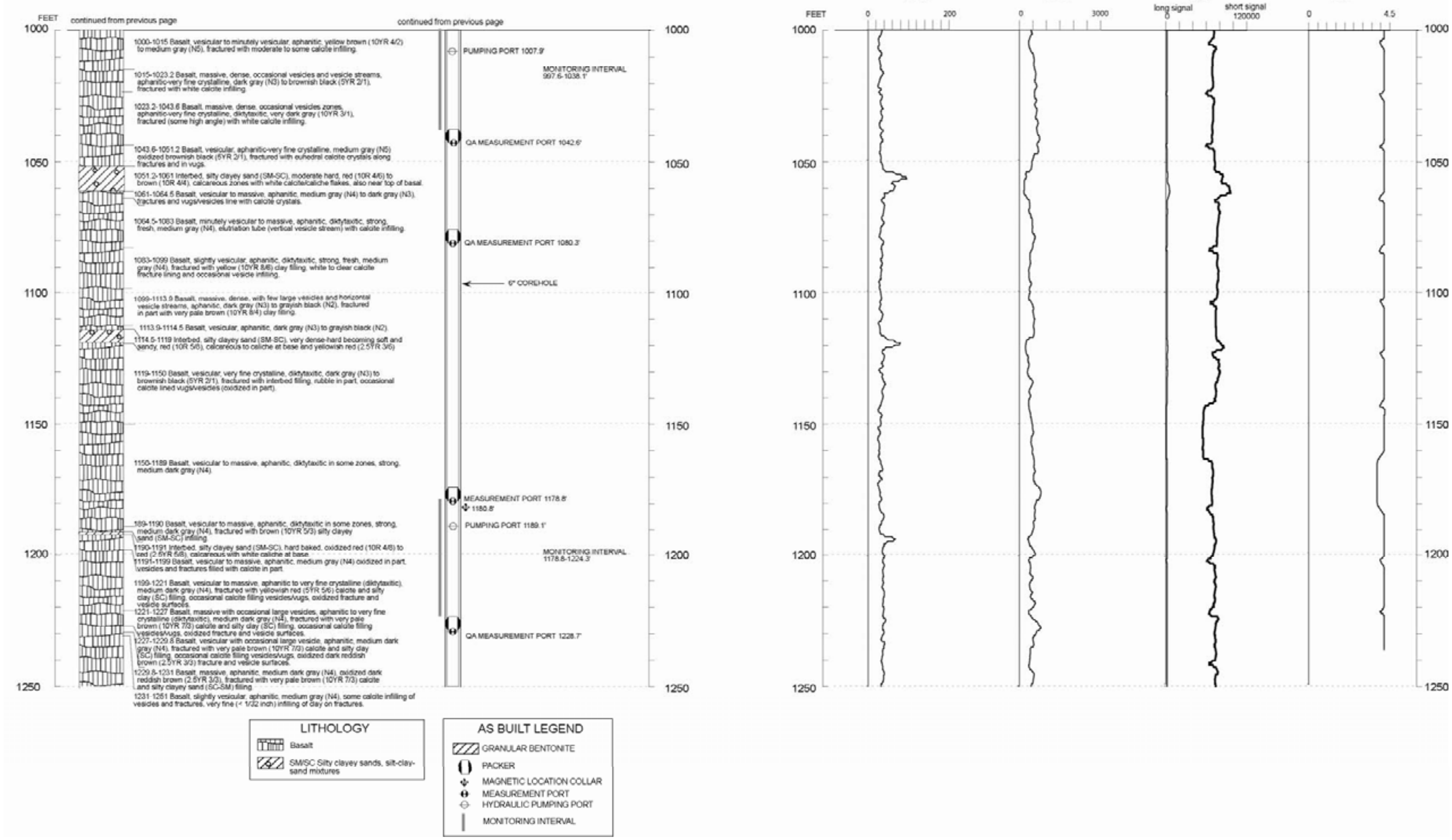
750
800
850
900
950
1000
752.5-756.7 Basalt, vesicular, aphanitic, medium dark gray (N4) to dark gray (N3).
756.7-762.5 Basalt, massive, few large vesicles, with white calcite lining, some forming small crystals, dense, fresh, aphanitic, medium dark gray (N4) to dark gray (N3).
762.5-768 Basalt, vesicular, aphanitic, medium dark gray (N4) to dark gray (N3), fractured with reddish yellow (5YR 7/6), calcareous silt filling, rubble zone in part, oxidized reddish brown (2.5Y 4/4) along fractures, white calcite filling vugs in part.
768-769.5 Basalt, massive, aphanitic, medium dark gray (N4) to dark gray (N3).
769.5-779.5 Basalt, vesicular, aphanitic, medium dark gray (N4) to dark gray (N3), fractured with very pale yellow (10YR 8/2) calcareous clay filling, rubble zone in part.
779.5-794 Basalt, slightly vesicular, aphanitic-very fine crystalline, diktytaxitic in part, medium dark gray (N4), fractured in part with very pale yellow (10YR 8/2) calcareous clay filling.
794-806 Basalt, vesicular to massive-dense, aphanitic-very fine crystalline, diktytaxitic in part, medium dark gray (N4), fractured in part to rubble with reddish yellow (7.5YR 6/6) calcareous clay filling, fracture surfaces oxidized reddish brown (2.5YR 4/4), few large vesicles and fractures filled with white calcite.
806-811.5 Basalt, massive, dense, aphanitic-very fine crystalline, diktytaxitic in part, medium dark gray (N4), with factures and a few large vesicles filled with white calcite.
811.5-831 Basalt, vesicular, aphanitic, medium dark gray (N4) to dark gray (N3), with factures becoming rubble/cinder zone oxidized dark red (10R3/6) with very pale brown (10YR 8/3) calcareous clay filling, few large vesicles.
831-844 Basalt, slightly vesicular to massive, dense, aphanitic, medium dark gray (N4), fractured in part with very little very pale brown (10YR 8/3) calcareous clay filling, few vesicles filled with white calcite.
844-865 Basalt, vesicular to minutely vesicular, aphanitic, medium dark gray (N4) to dark gray (N3), fractured with yellowish red (5YR 5/6) calcareous clay filling, calcite filling and coating of vesicles.
865-870 Basalt, vesicular to minutely vesicular, aphanitic, medium strong, medium gray (N5) fresh to slightly weathered grayish red (10R 4/2), fractured with yellowish red (5YR 5/6) calcareous clay filling, calcite filling and coating of vesicles.
870-886 Basalt, slightly vesicular to minutely vesicular, fresh, aphanitic, diktytaxitic zones, medium gray (N5) to reddish brown (5YR 5/3), fractured with heav infilling of calcite.
886-900 Basalt, slightly vesicular to vesicular, aphanitic, medium gray (N5) to reddish brown (5YR 5/3), fractured with infilling of reddish brown (2.5YR 4/4) calcareous clay, vesicles contain brownish yellow (10YR 6/6) clay infill.
900-906.5 Basalt, slightly vesicular, aphanitic, medium strong, medium gray (N5) fresh to slightly weathered brownish gray (5YR 4/1).
906.5-907.3 Interbed, baked silts and clay (SC), red (10R 4/6).
907.4-914 Basalt, vesicular to slightly vesicular, aphanitic, medium strong, medium gray (N4) weathered brownish gray (5YR 4/1), fractured in part with calcite infilling of both fractures and vesicles.
914-919.5 Basalt, massive with vesicular zones and few large vesicles, aphanitic, diktytaxitic, very dark gray (10YR 3/1), fractured in part.
919.5-924 Basalt, vesicular, aphanitic, very dark gray (10YR 3/1), oxidized dark reddish gray (2.5YR 3/1) and red (10R 4/6) along fractures, occasional white calcite filling.
924-926 Basalt, massive-dense to slightly vesicular, aphanitic-very fine crystalline, diktytaxitic, medium gray (N4), occasional white calcite fracture filling.
926-935.3 Basalt, vesicular, aphanitic, very dark gray (5YR 3/1), fractured with dark red (10R 3/6) oxidized staining fracture surfaces and occasional white calcite filling.
935.3-937 Basalt, massive, dense, aphanitic-very fine crystalline, diktytaxitic in part, medium gray (N5), occasional white calcite fracture filling.
937-942 Basalt, vesicular, aphanitic, medium gray (N5), highly fractured to rubble, oxidized dark red (10R 3/6), occasional white calcite vesicle filling.
942-953 Basalt, vesicular, aphanitic with visible feldspar crystals, diktytaxitic, dark gray (N3) to brownish black (5YR 2/1), highly fractured to rubble/cinder, oxidized dark red (10R 3/6), occasional white calcite vesicle and fracture filling.
953-961 Basalt, massive, dense, vesicular in part, aphanitic-very fine crystalline, diktytaxitic, medium gray (N5) oxidized brownish black (5YR 2/1), occasional white calcite vugs/vesicle filling.
961-975 Basalt, massive, dense, vesicular in part, aphanitic-very fine crystalline, diktytaxitic, medium gray (N5) to medium dark gray (N4), oxidized brownish black (5YR 2/1), occasional white calcite vugs/vesicle filling.
975-985 Basalt, minutely vesicular to vesicular, aphanitic, diktytaxitic in zones, fresh, strong to very strong, dark gray (N3).
985-990 Basalt, inferred flow top, vesicular, aphanitic, strong to very strong, slightly weathered, grayish red (5R 4/2), fractures contain heavy (up to 1/2 inch) infilling of calcite crystals.
990-1000 Basalt, slightly vesicular to minutely vesicular, aphanitic, fresh, diktytaxitic in zones, medium dark gray (N4).
MEASUREMENT PORT AT 790.2'
792.2'
MONITORING INTERVAL 786.9-804.5'
PUMPING PORT AT 800.5'
QA MEASUREMENT PORT AT 809'
QA MEASUREMENT PORT AT 841.7'
6" COREHOLE
MONITORING INTERVAL 997.6-1038.1'
MEASUREMENT PORT 997.6'
999.6'
AS BUILT LEGEND
GRANULAR BENTONITE
PACKER
MAGNETIC LOCATION COLLAR
MEASUREMENT PORT
HYDRAULIC PUMPING PORT
MONITORING INTERVAL
LITHOLOGY
Basalt
SC Clayey sands, sand-clay mixtures


FEET
Natural Gamma API-GR
0
200
Neutron API-N
0
3000
Gamma Gamma CPS
long signal 0
short signal 120000
Caliper INCH
0
4.5
750
800
850
900
950
1000


FEET
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1000
1050
1100
1150
1200
1250
1000-1015 Basalt, vesicular to minutely vesicular, aphanitic, yellow brown (10YR 4/2) to medium gray (N5), fractured with moderate to some calcite infilling.
1015-1023.2 Basalt, massive, dense, occasional vesicles and vesicle streams, aphanitic-very fine crystalline, dark gray (N3) to brownish black (5YR 2/1), fractured with white calcite infilling.
1023.2-1043.6 Basalt, massive, dense, occasional vesicles zones, aphanitic-very fine crystalline, diktytaxitic, very dark gray (10YR 3/1), fractured (some high angle) with white calcite infilling.
1043.6-1051.2 Basalt, vesicular, aphanitic-very fine crystalline, medium gray (N5) oxidized brownish black (5YR 2/1), fractured with euhedral calcite crystals along fractures and in vugs.
1051.2-1061 Interbed, silty clayey sand (SM-SC), moderate hard, red (10R 4/6) to brown (10R 4/4), calcareous zones with white calcite/caliche flakes, also near top of basal.
1061-1064.5 Basalt, vesicular to massive, aphanitic, medium gray (N4) to dark gray (N3), fractures and vugs/vesicles line with calcite crystals.
1064.5-1083 Basalt, minutely vesicular to massive, aphanitic, diktytaxitic, strong, fresh, medium gray (N4), elutriation tube (vertical vesicle stream) with calcite infilling.
1083-1099 Basalt, slightly vesicular, aphanitic, diktytaxitic, strong, fresh, medium gray (N4), fractured with yellow (10YR 8/6) clay filling, white to clear calcite fracture lining and occasional vesicle infilling.
1099-1113.9 Basalt, massive, dense, with few large vesicles and horizontal vesicle streams, aphanitic, dark gray (N3) to grayish black (N2), fractured in part with very pale brown (10YR 8/4) clay filling.
1113.9-1114.5 Basalt, vesicular, aphanitic, dark gray (N3) to grayish black (N2).
1114.5-1119 Interbed, silty clayey sand (SM-SC), very dense-hard becoming soft and sandy, red (10R 5/6), calcareous to caliche at base and yellowish red (2.5YR 3/6)
1119-1150 Basalt, vesicular, very fine crystalline, diktytaxitic, dark gray (N3) to brownish black (5YR 2/1), fractured with interbed filling, rubble in part, occasional calcite lined vugs/vesicles (oxidized in part).
1150-1189 Basalt, vesicular to massive, aphanitic, diktytaxitic in some zones, strong, medium dark gray (N4).
1189-1190 Basalt, vesicular to massive, aphanitic, diktytaxitic in some zones, strong, medium dark gray (N4), fractured with brown (10YR 5/3) silty clayey sand (SM-SC) infilling.
1190-1191 Interbed, silty clayey sand (SM-SC), hard baked, oxidized red (10R 4/6) to red (2.5YR 5/8), calcareous with white caliche at base.
1191-1199 Basalt, vesicular to massive, aphanitic, medium gray (N4) oxidized in part, vesicles and fractures filled with calcite in part.
1199-1221 Basalt, vesicular to massive, aphanitic to very fine crystalline (diktytaxitic), medium dark gray (N4), fractured with yellowish red (5YR 5/6) calcite and silty clay (SC) filling, occasional calcite filling vesicles/vugs, oxidized fracture and vesicle surfaces.
1221-1227 Basalt, massive with occasional large vesicles, aphanitic to very fine crystalline (diktytaxitic), medium dark gray (N4), fractured with very pale brown (10YR 7/3) calcite and silty clay (SC) filling, occasional calcite filling vesicles/vugs, oxidized fracture and vesicle surfaces.
1227-1229.8 Basalt, vesicular with occasional large vesicle, aphanitic, medium dark gray (N4), fractured with very pale brown (10YR 7/3) calcite and silty clay (SC) filling, occasional calcite filling vesicles/vugs, oxidized dark reddish brown (2.5YR 3/3) fracture and vesicle surfaces.
1229.8-1231 Basalt, massive, aphanitic, medium dark gray (N4), oxidized dark reddish brown (2.5YR 3/3), fractured with very pale brown (10YR 7/3) calcite and silty clayey sand (SC-SM) filling.
1231-1251 Basalt, slightly vesicular, aphanitic, medium gray (N4), some calcite infilling of vesicles and fractures, very fine (< 1/32 inch) infilling of clay on fractures.
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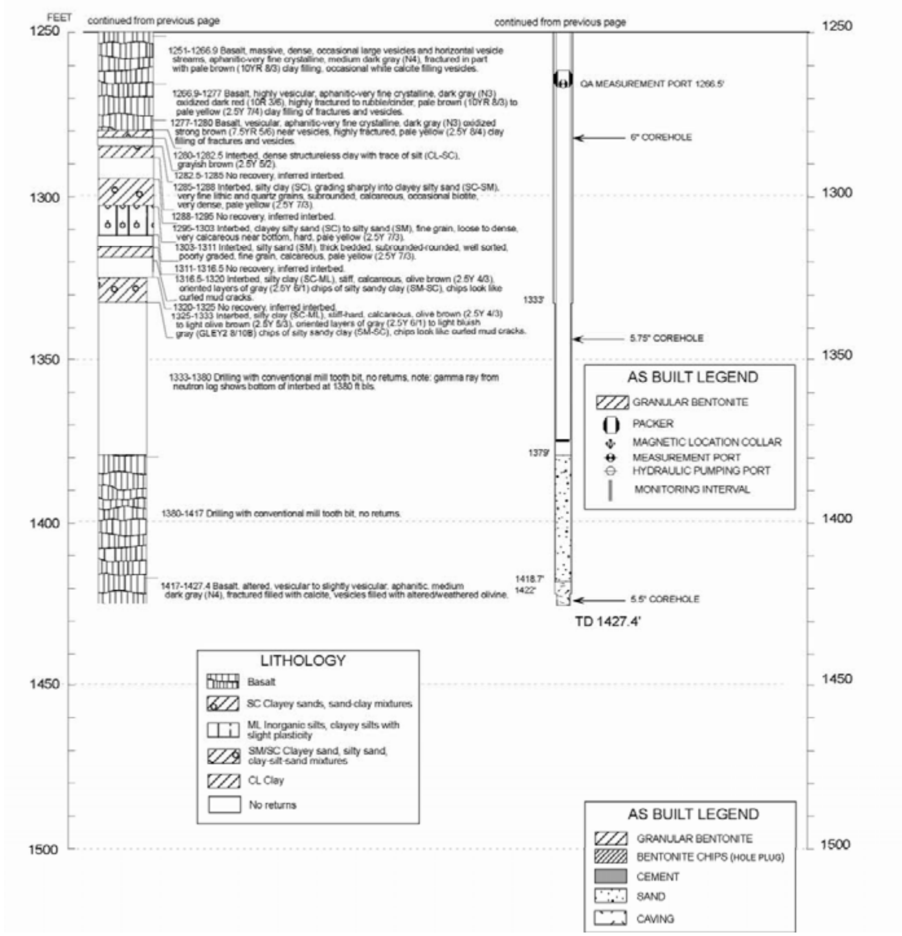
PUMPING PORT 1007.9'
MONITORING INTERVAL 997.6-1038.1'
QA MEASUREMENT PORT 1042.6'
QA MEASUREMENT PORT 1080.3'
6" COREHOLE
MEASUREMENT PORT 1178.8'
1180.8'
PUMPING PORT 1189.1'
MONITORING INTERVAL 1178.8-1224.3'
QA MEASUREMENT PORT 1228.7'
LITHOLOGY
Basalt
SM/SC Silty clayey sands, silt-clay-sand mixtures
AS BUILT LEGEND
GRANULAR BENTONITE
PACKER
MAGNETIC LOCATION COLLAR
MEASUREMENT PORT
HYDRAULIC PUMPING PORT
MONITORING INTERVAL
Natural Gamma API GR
0
200
Neutron API N
0
3000
Gamma Gamma CPS
long signal
short signal
0
120000
Caliper INCH
0
4.5


FEET
1250
1300
1350
1400
1450
1500
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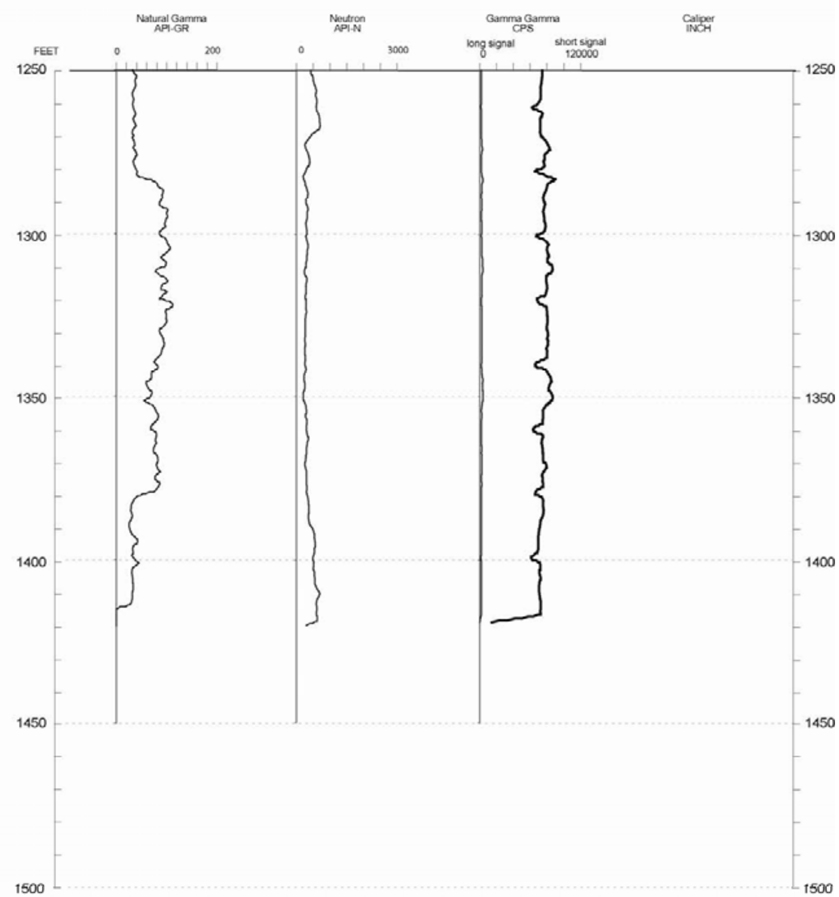
1251-1266.9 Basalt, massive, dense, occasional large vesicles and horizontal vesicle streams, aphanitic-very fine crystalline, medium dark gray (N4), fractured in part with pale brown (10YR 8/3) clay filling, occasional white calcite filling vesicles.
1266.9-1277 Basalt, highly vesicular, aphanitic-very fine crystalline, dark gray (N3) oxidized dark red (10R 3/6), highly fractured to rubble/cinder, pale brown (10YR 8/3) to pale yellow (2.5Y 7/4) clay filling of fractures and vesicles.
1277-1280 Basalt, vesicular, aphanitic-very fine crystalline, dark gray (N3) oxidized strong brown (7.5YR 5/6) near vesicles, highly fractured, pale yellow (2.5Y 8/4) clay filling of fractures and vesicles.
1280-1282.5 Interbed, dense structureless clay with trace of silt (CL-SC), grayish brown (2.5Y 5/2).
1282.5-1285 No recovery, inferred interbed.
1285-1288 Interbed, silty clay (SC), grading sharply into clayey silty sand (SC-SM), very fine lithic and quartz grains, subrounded, calcareous, occasional biotite, very dense, pale yellow (2.5Y 7/3).
1288-1295 No recovery, inferred interbed.
1295-1303 Interbed, clayey silty sand (SC) to silty sand (SM), fine grain, loose to dense, very calcareous near bottom, hard, pale yellow (2.5Y 7/3).
1303-1311 Interbed, silty sand (SM), thick bedded, subrounded-rounded, well sorted, poorly graded, fine grain, calcareous, pale yellow (2.5Y 7/3).
1311-1316.5 No recovery, inferred interbed.
1316.5-1320 Interbed, silty clay (SC-ML), stiff, calcareous, olive brown (2.5Y 4/3), oriented layers of gray (2.5Y 6/1) chips of silty sandy clay (SM-SC), chips look like curled mud cracks.
1320-1325 No recovery, inferred interbed.
1325-1333 Interbed, silty clay (SC-ML), stiff-hard, calcareous, olive brown (2.5Y 4/3) to light olive brown (2.5Y 5/3), oriented layers of gray (2.5Y 6/1) to light bluish gray (GLEY2 8/10B) chips of silty sandy clay (SM-SC), chips look like curled mud cracks.
1333-1380 Drilling with conventional mill tooth bit, no returns, note: gamma ray from neutron log shows bottom of interbed at 1380 ft bls.
1380-1417 Drilling with conventional mill tooth bit, no returns.
1417-1427.4 Basalt, altered, vesicular to slightly vesicular, aphanitic, medium dark gray (N4), fractured filled with calcite, vesicles filled with altered/weathered olivine.
QA MEASUREMENT PORT 1266.5'
6" COREHOLE
1333'
5.75" COREHOLE
1379'
1418.7'
1422'
5.5" COREHOLE
TD 1427.4'
AS BUILT LEGEND
GRANULAR BENTONITE
PACKER
MAGNETIC LOCATION COLLAR
MEASUREMENT PORT
HYDRAULIC PUMPING PORT
MONITORING INTERVAL
LITHOLOGY
Basalt
SC Clayey sands, sand-clay mixtures
ML Inorganic silts, clayey silts with slight plasticity
SM/SC Clayey sand, silty sand, clay-silt-sand mixtures
CL Clay
No returns
AS BUILT LEGEND
GRANULAR BENTONITE
BENTONITE CHIPS (HOLE PLUG)
CEMENT
SAND
CAVING


FEET
Natural Gamma
API-GR
0
200
Neutron
API-N
0
3000
Gamma Gamma
CPS
long signal
0
short signal
120000
Caliper
INCH
1250
1300
1350
1400
1450
1500

WELL NAME: **MIDDLE-2051**

Facility: INL-CFA Area

Well Type: Exploratory Core Hole/Monitoring

Well Status: Active

Year Drilled: 2005

Total Depth: 1179.'

Drilling Start Date: 1/19/05 End Date: 5/18/05

Completion Start Date: 5/18/05 End Date: 10/3/05

Completion Depth: 1177'

Driller: Major Drilling/Rosario, Jensen, Gordon

Geologist: Oberhansley, Bailey, Whitmore

Drill Method: Air Rotary/ Conventional Coring

Drill Fluid: Air/QuickFoam/Water

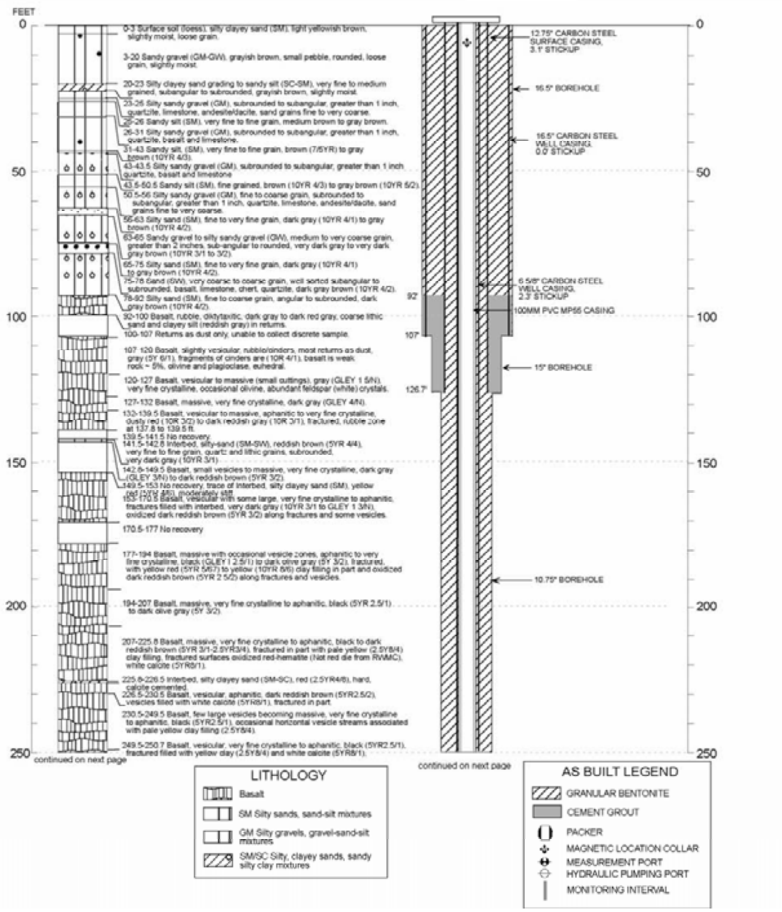
Elevation: (29 BC) (29 MP) (88 BC) (88MP)

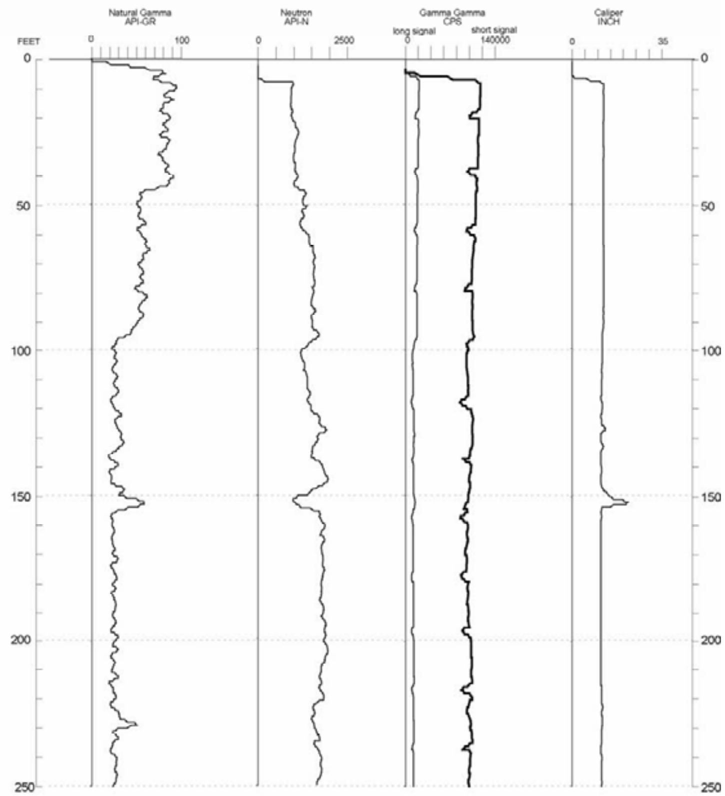
Todays Date: 2/6/06

Water Level: 571'

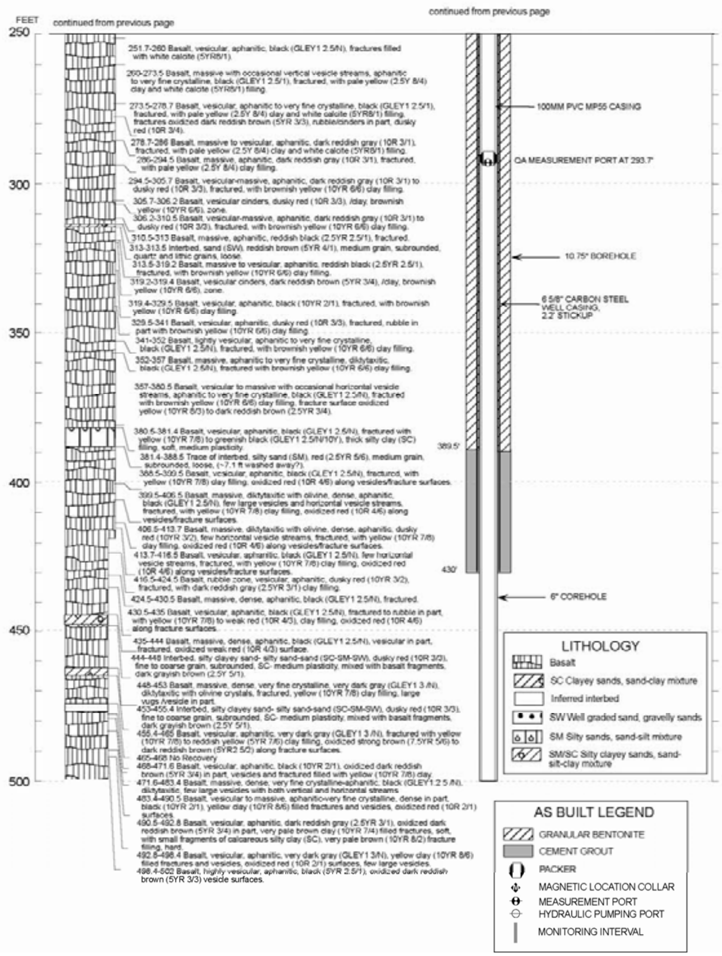
Water Level Date: 8/18/05

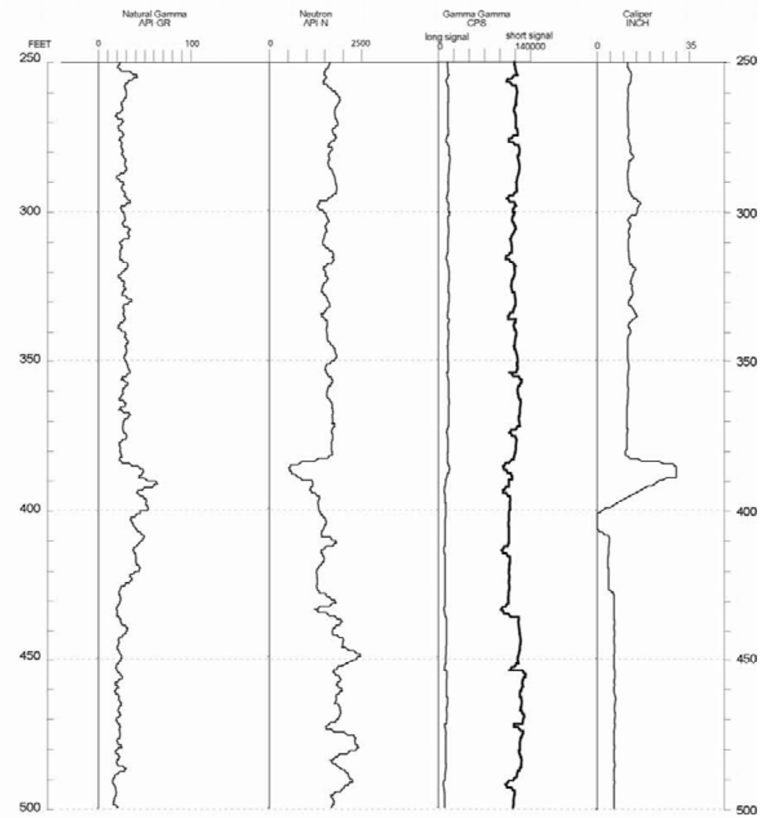
Water Level Access: 100mm PVC





WELL NAME: **MIDDLE-2051**





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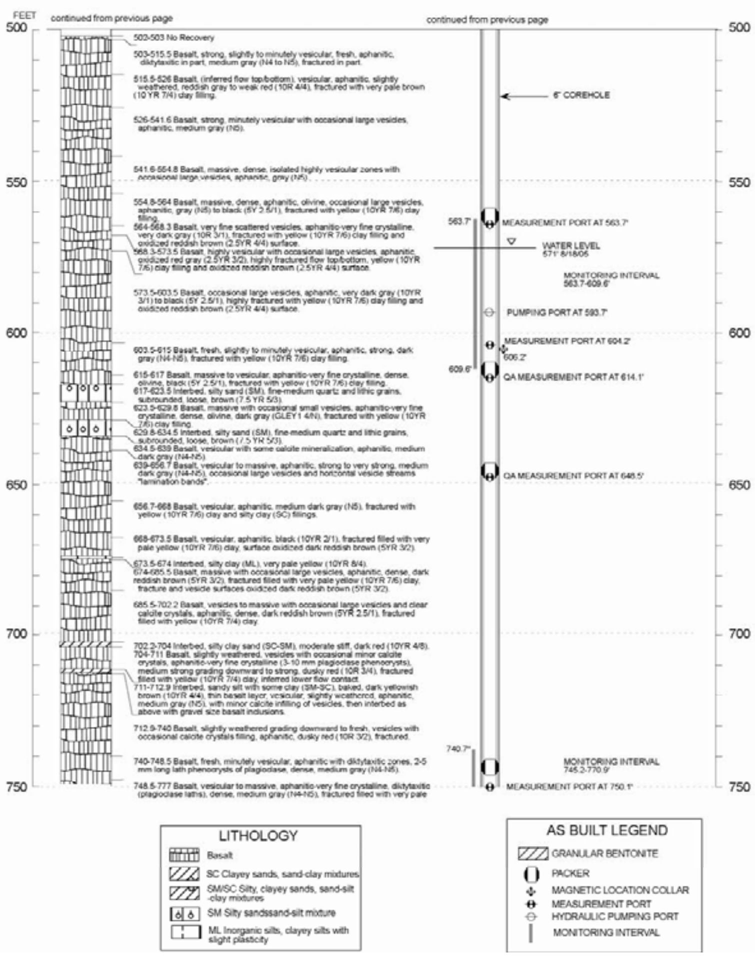

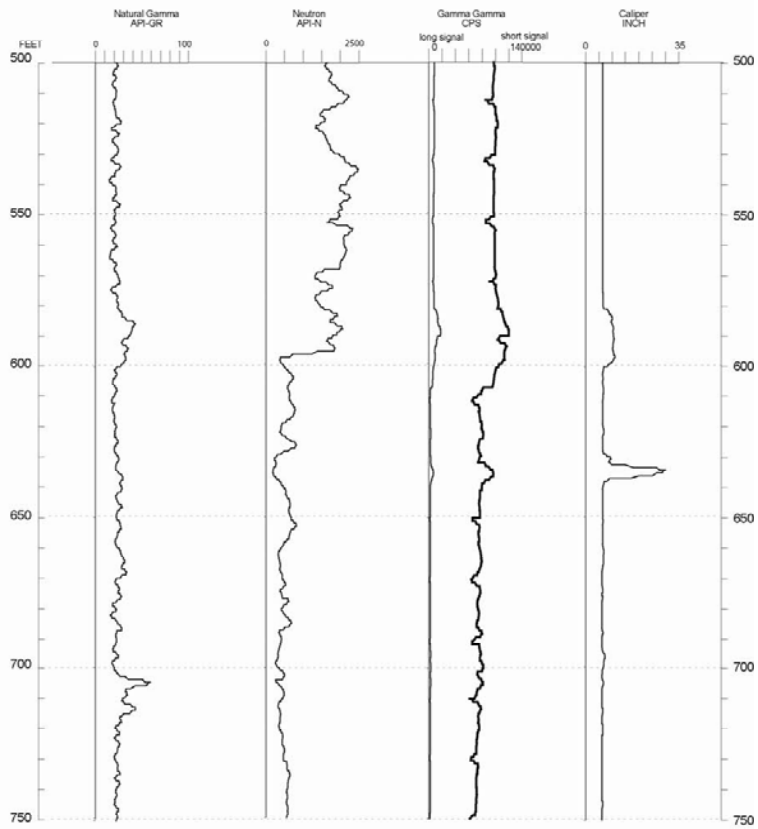

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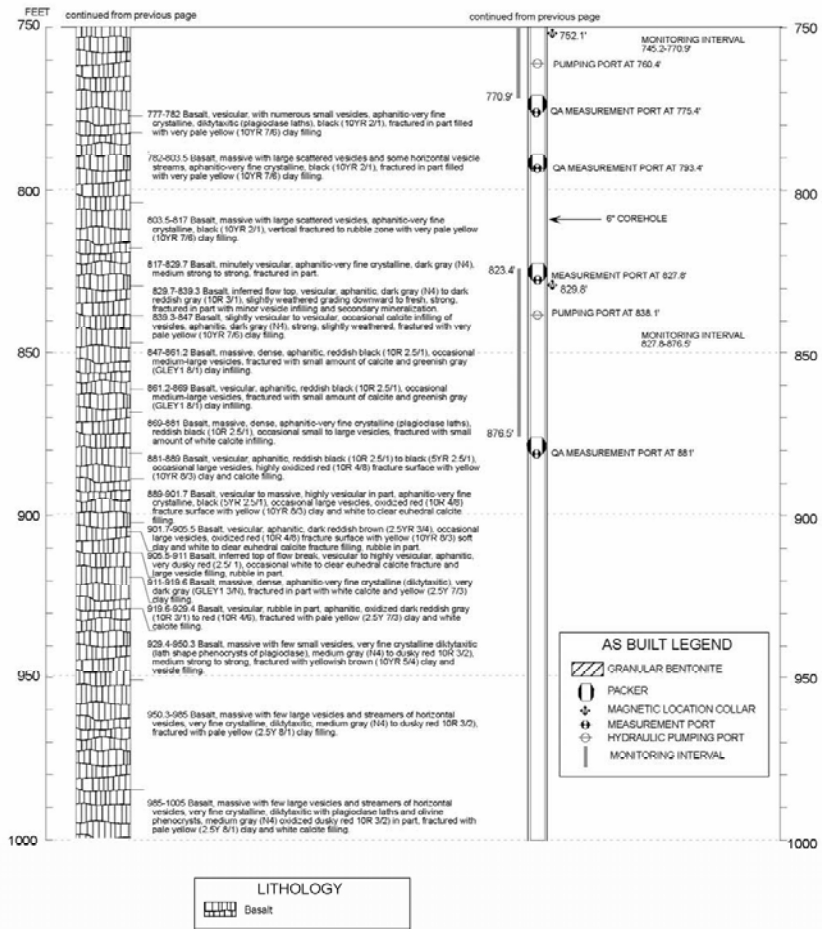
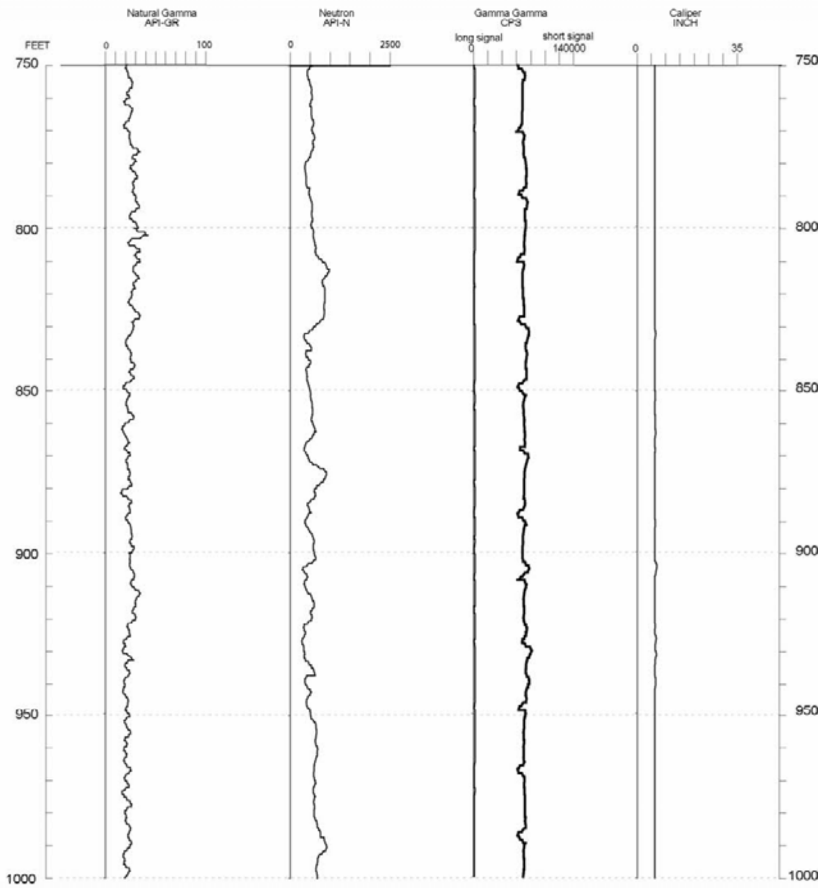
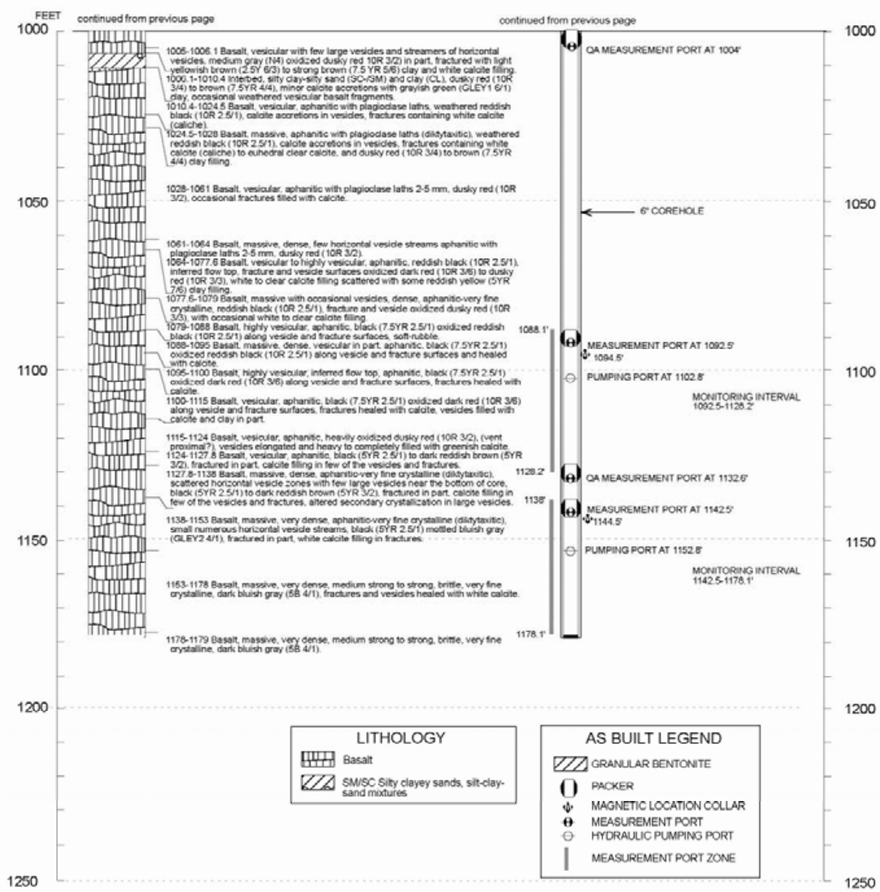
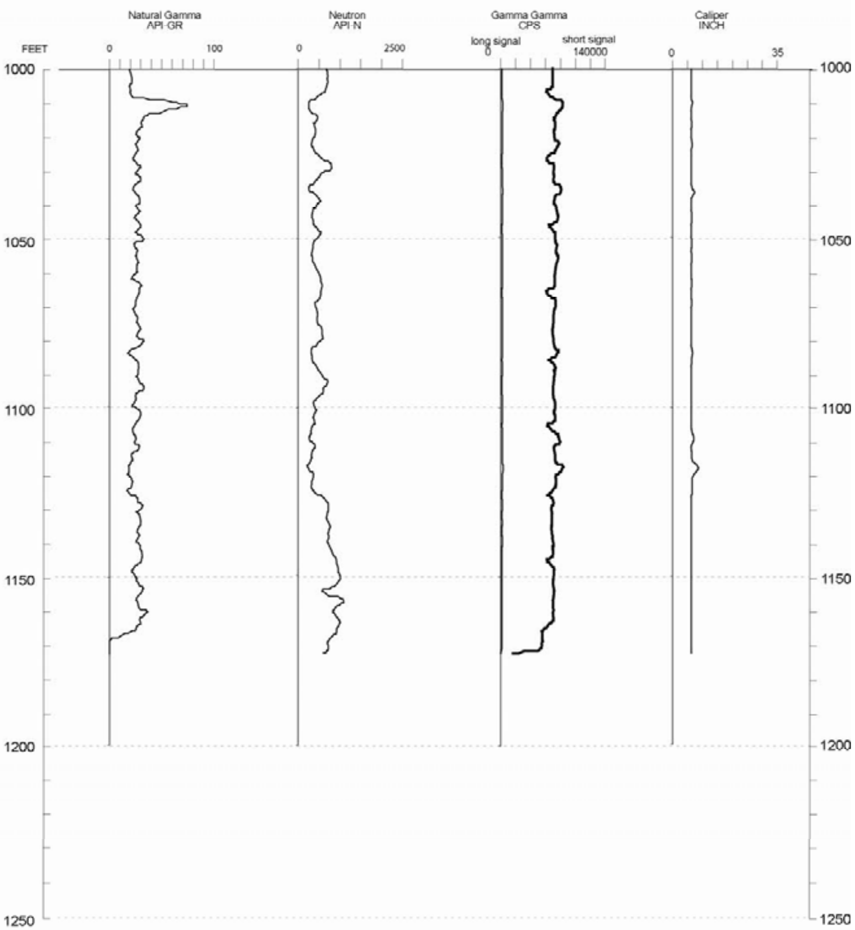





FEET
continued from previous page
continued from previous page
1000
1050
1100
1150
1200
1250
1005-1006.1 Basalt, vesicular with few large vesicles and streamers of horizontal vesicles, medium gray (N4) oxidized dusky red 10R 3/2) in part, fractured with light yellowish brown (2.5Y 6/3) to strong brown (7.5 YR 5/6) clay and white calcite filling.
1006.1-1010.4 Interbed, silty clay-silty sand (SC-/SM) and clay (CL), dusky red (10R 3/4) to brown (7.5YR 4/4), minor calcite accretions with grayish green (GLEY1 6/1) clay, occasional weathered vesicular basalt fragments.
1010.4-1024.5 Basalt, vesicular, aphanitic with plagioclase laths, weathered reddish black (10R 2.5/1), calcite accretions in vesicles, fractures containing white calcite (caliche).
1024.5-1028 Basalt, massive, aphanitic with plagioclase laths (diktytaxitic), weathered reddish black (10R 2.5/1), calcite accretions in vesicles, fractures containing white calcite (caliche) to euhedral clear calcite, and dusky red (10R 3/4) to brown (7.5YR 4/4) clay filling.
1028-1061 Basalt, vesicular, aphanitic with plagioclase laths 2-5 mm, dusky red (10R 3/2), occasional fractures filled with calcite.
1061-1064 Basalt, massive, dense, few horizontal vesicle streams aphanitic with plagioclase laths 2-5 mm, dusky red (10R 3/2).
1064-1077.6 Basalt, vesicular to highly vesicular, aphanitic, reddish black (10R 2.5/1), inferred flow top, fracture and vesicle surfaces oxidized dark red (10R 3/6) to dusky red (10R 3/3), white to clear calcite filling scattered with some reddish yellow (5YR 7/6) clay filling.
1077.6-1079 Basalt, massive with occasional vesicles, dense, aphanitic-very fine crystalline, reddish black (10R 2.5/1), fracture and vesicle oxidized dusky red (10R 3/3), with occasional white to clear calcite filling.
1079-1088 Basalt, highly vesicular, aphanitic, black (7.5YR 2.5/1) oxidized reddish black (10R 2.5/1) along vesicle and fracture surfaces, soft-rubble.
1088-1095 Basalt, massive, dense, vesicular in part, aphanitic, black (7.5YR 2.5/1) oxidized reddish black (10R 2.5/1) along vesicle and fracture surfaces and healed with calcite.
1095-1100 Basalt, highly vesicular, inferred flow top, aphanitic, black (7.5YR 2.5/1) oxidized dark red (10R 3/6) along vesicle and fracture surfaces, fractures healed with calcite.
1100-1115 Basalt, vesicular, aphanitic, black (7.5YR 2.5/1) oxidized dark red (10R 3/6) along vesicle and fracture surfaces, fractures healed with calcite, vesicles filled with calcite and clay in part.
1115-1124 Basalt, vesicular, aphanitic, heavily oxidized dusky red (10R 3/2), (vent proximal?), vesicles elongated and heavy to completely filled with greenish calcite.
1124-1127.8 Basalt, vesicular, aphanitic, black (5YR 2.5/1) to dark reddish brown (5YR 3/2), fractured in part, calcite filling in few of the vesicles and fractures.
1127.8-1138 Basalt, massive, dense, aphanitic-very fine crystalline (diktytaxitic), scattered horizontal vesicle zones with few large vesicles near the bottom of core, black (5YR 2.5/1) to dark reddish brown (5YR 3/2), fractured in part, calcite filling in few of the vesicles and fractures, altered secondary crystallization in large vesicles.
1138-1153 Basalt, massive, very dense, aphanitic-very fine crystalline (diktytaxitic), small numerous horizontal vesicle streams, black (5YR 2.5/1) mottled bluish gray (GLEY2 4/1), fractured in part, white calcite filling in fractures.
1153-1178 Basalt, massive, very dense, medium strong to strong, brittle, very fine crystalline, dark bluish gray (5B 4/1), fractures and vesicles healed with white calcite.
1178-1179 Basalt, massive, very dense, medium strong to strong, brittle, very fine crystalline, dark bluish gray (5B 4/1).
QA MEASUREMENT PORT AT 1004'
6" COREHOLE
1088.1'
MEASUREMENT PORT AT 1092.5'
1094.5'
PUMPING PORT AT 1102.8'
MONITORING INTERVAL 1092.5-1128.2'
1128.2'
QA MEASUREMENT PORT AT 1132.6'
1138'
MEASUREMENT PORT AT 1142.5'
1144.5'
PUMPING PORT AT 1152.8'
MONITORING INTERVAL 1142.5-1178.1'
1178.1'
LITHOLOGY
Basalt
SM/SC Silty clayey sands, silt-clay-sand mixtures
AS BUILT LEGEND
GRANULAR BENTONITE
PACKER
MAGNETIC LOCATION COLLAR
MEASUREMENT PORT
HYDRAULIC PUMPING PORT
MEASUREMENT PORT ZONE


FEET
Natural Gamma API-GR
0
100
Neutron API-N
0
2500
Gamma Gamma CPS
long signal 0
short signal 140000
Caliper INCH
0
35
1000
1050
1100
1150
1200
1250